Essays on Energy Reforms, Regulation and Institutions

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Abstract

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This thesis contents a doctoral research that examines whether implementations of the reforms have succeeded in reducing the negative influence of weak institutions on Sub-Saharan African (SSA) countries' electricity sector performance. Chapter 1 of the thesis examines how corruption contributes to low levels of economic development of SSA countries, defines the concept of corruption and discusses its major determinants as it relates to the region.

By using a panel data on 48 SSA covering the period 2002 to 2013, chapter 2 investigates how corruption could negatively affect electricity sector performance of SSA countries, and how this performance effects of corruption would be mitigated or amplified by implementations of electricity sector reform policies. The findings show that corruption can significantly reduce technical efficiency of the sector and constrain the efforts to increase access to electricity and national income. However, these adverse effects of corruption are reduced when independent regulatory agencies are established, and privatisation is implemented.

Chapter 3 extents the findings of chapter 2 by using data on 45 SSA governments from 2000 to 2015 to investigate the ideological differences in the effect of independent sector regulation on access to electricity and installed capacity. The findings suggest that independent regulation in left-wing governments deteriorates both installed capacity and electricity access. However, independent regulation in right-wing governments improves installed capacity and has no significant impact on electricity access.

Chapter 4 uses data on 49 SSA countries from 2002 to 2013 to examine the impact of electricity access on human development index (HDI) and its three components (health, education, and income) post the implementations of electricity sector reforms and other policies by SSA countries. The findings indicate that increased access to electricity has positively boosted human development. Similar results are found on the impact of electricity access on the three components of HDI.

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Declaration

None of the material contained in this thesis has been submitted for a degree in any other university. The results contained in some of the empirical chapters are based on joint research articles with my supervisors, Professor Tooraj Jamasb and Doctor Manuel Llorca. Where material is drawn from this joint work, proper reference has been made. This thesis has been funded by Tertiary Education Trust Fund (Tetfund), Nigeria.

Statement of Copyright

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Dedication

In the memory of my late parents, Kachalla Mahmud and Zara Zannah Dalatu.

Chapter 1: Corruption and Economic Development

1.1. Introduction

According to the United Nations (2013), rapid economic growth in developing countries has helped uplift millions of people out of poverty on an unprecedented scale in last three decades. However, in SSA, corruption continues to hold back the efforts to translate the benefits of economic growth into improvements in living standards. For example, despite the optimistic assessment by the United Nations report, millions in the region continue to be trapped in poverty (Transparency International, 2012) because corruption acting as a regressive tax diverts resources from their productive uses (Mauro, 1998) towards supporting the lifestyles of the elites at the expense of the poor (Gupta et al., 2002).

A considerable number of theoretical and empirical investigations have found how corruption could distort the economy through various channels and thereby have adverse effects on economic development (e.g., Mauro, 1995; Knack and Keefer, 1997; Sachs and Warner, 2001; Li et al., 2000; Mo, 2001; Gyimah-Brempong, 2002; UNDP, 1997; Wei 2000; Tanzi, 1998; Gupta et al., 2001). These channels include acting as a tax on investment thereby stifling the creation of new businesses, as an obstacle to doing business, and the possibility of corruption to cause misallocation of public expenditure, taxation, composition and effectiveness public expenditure on infrastructure.

Corruption also distorts incentives and market forces, misallocates resources, diverts talent and resources, including human resources, towards "lucrative" rent-seeking activities, such as defence, rather than productive activities (Transparency International, 2014). Corruption can generate undesirable outcomes even when economic policies and plans were well thought out and implemented. As a result of its adverse effects, the World Bank (2000) described it as the single greatest threat to economic and social development as it distorts the rule of law and

weakens the institutional framework on which economic development depends.

Notwithstanding these, there are other conflicting views on the corruption-economic development nexus. As a result, views on the relationship are diverse and have polarised both economists and policymakers. For example, Leff (1964), Huntington (1968), and Lui (1985) argued that corruption is a beneficial grease that lubricates the engine of economic growth. Acemoglu and Verdier (1998) similarly argue that some degree of corruption may form part of an optimal allocation of resources in the presence of incomplete contracts or market failures. These arguments tend to underpin the views that corruption serves as a piece-rate payment to politicians and bureaucrats and therefore leads to more efficient provision of government services, while providing a leeway for businesses to bypass inefficient regulations. Overall, corruption is viewed as a lubricant that smoothens operations and thereby raises the efficiency of an economy (Mo, 2000).

Despite these conflicting views on the economic development-corruption nexus, there is a common consensus among policymakers and development experts that corruption is a major contributor to the developmental challenges faced by SSA countries. The negative economic development consequences of corruption in SSA countries are attributed to weak and fragmented institutions that usually fail to constraint corruption related activities (Gyimah-Brempong and Camacho, 2006). As a result, most of the studies in the corruption literature on SSA countries tend to investigate the effects of corruption on economic development indirectly through institutional quality.

Recently different variants of this literature have emerged to extend the economic development effects of corruption to other specific channels. In a study relevant to this research, Tanzi and Davoodi (1997) show that corruption can affect economic performance, by reducing the quality of public infrastructure. Corruption can also affect the quality infrastructure through its negative effects on Foreign Direct Investments (FDI) needed to

upgrade and expand access especially in developing countries that lack required resources. For example, Gani (2007) finds evidence that show FDI is positively correlated with governance indicators such as rule of law, control of corruption, regulatory quality, among others. Wei (2001) also finds corruption as a significant factor that reduces inflow of FDI. In a similar study of United States FDI outflows to 42 countries, Sanyal and Samanta (2008) noted that US firms are less incline in investing in countries considered as highly corrupt.

It is within this context that this thesis focuses on how corruption would affect economic development through the operation and regulations of electricity networks. For example, corruption can affect important indicators of economic development by reducing the productivity of workers, constraint efforts to extend electricity services to the millions without access in the region and limit the inflow of investments needed to increase the overall efficiency of the sector.

By inhibiting electricity sector performance, corruption would indirectly inhibit the operations of modern communications, industrial development and constraint the provision of social services such as healthcare and education. In some countries such as Nigeria, failure to pay bribes to utilities workers in exchange for basic services usually results in curtailing electricity supply to certain areas (Olukoju 2004), thereby having deleterious impact on economic development. In SSA countries, a 1% increase in electricity shortages has been estimated to have reduced GDP per capita by 2.86% between 1995 and 1997 (Anderson and Dalgaard, 2013). Thus, the constraining effects of corruption on electricity sector performance to boost economic performance.

1.2. Definition of corruption

Almost all studies that seek to analyse issues related to corruption tend to begin with a definition of corruption (Jain, 2001). It may be tempting to question the necessity of this

approach, but the relevance of this should not be underestimated. This is because, the fact that corruption is a complex concept and the likelihood that it can exist in many contexts, makes it inherently difficult to define. Therefore, in order to have a grasp of what it is, a discussion of the concept is valuable.

The consequences and causes of corruption have been studied not only in recent times but have a long history in economics that may date back to the seminal contributions of rent-seeking by Krueger (1974), Rose-Ackerman (1978) and Bhagwati (1982). Although, Horwitz (1982) has stated that corruption is a recent phenomenon because the concept of 'public' and 'private' ownership did not exist in the past, Lipset and Lenz (2000) argue that issues related to corruption are as old as the world itself. There is no consensus on the exact meaning of corruption as it has been defined differently under different conditions to encompass a wide range of misconduct. According to Aliyu and Elijah (2008), corruption covers a wide range of social misconduct ranging from extortion, embezzlement, massive fraud, nepotism, rigging of elections, influence peddling, bribery, abuse of public property, and sale of fake or expired drugs among many.

Corruption has also been described as a clandestine activity which takes place away from the glare of public and hence, difficult to measure (Blackburn et al., 2006). According to Rose-Ackerman (1999), corruption exists when institutions that mean to regulate the relationship between the state and the citizens are used instead for personal enrichment and provision of benefits to the corrupt and undeserving. Thus, it is difficult to find a uniform definition of corruption because it depends not only on the profiteers, initiators, and on how and where it takes place but also on the existing laws and institutions guiding certain actions. It has been defined in its broadest form by some countries while others legislate on its narrow definition (Adenike, 2013). Whichever of the two definitions used by countries, corruption serves as a stumbling block to economic progress through its adverse effects on economic development.

As a result, corruption has different meanings to different people depending on the individual's political and cultural background, region, discipline or religious beliefs. Despite the absence of consistency in defining the concept, the chapter follows the Transparency International and Gyimah-Brempong (2002) to define corruption as the use of public office for private gain. However, Horwitz (1982) have argued that historically there has been no distinction between private and public property because political authority was regarded as a species of private property which could be handed down to descendants as part of their patrimony. Therefore, the idea that rulers cannot simply own their dominions and the notion that there will be potential conflict of interest between private and public was a recent phenomenon that started with the rise of modern European countries (Horwitz, 1982). In this regard, public can be broadly defined to include the political elites, international organizations, private businesses and government agencies. Following this view, therefore, there is the possibility that corruption can take place in any transaction that involves a public official. As defined in this fashion, corruption represents the special case of the principal-agent problem. Even though significant types of corruption are regarded as illegal, the chapter do not follow this approach and accept the view by Gyimah-Brempong and Camacho (2006) that not all corrupt practices are illegal, and not all illegal activities are regarded as corrupt practices.

Notwithstanding, the literature has identified three forms of corruption (Jain, 2001). First, grand corruption mostly associated with high-level political elites and regarded as the worst form of corruption. As policies enacted by the political elites are influenced by corruption and the incentive for corrupt practices, it may lead to the diversion of scarce resources (both natural and human resources), towards rent-seeking rather than productive activities. This may have severe long-run consequences on the economy. Political elites could also channel resources into unproductive sectors, such as defence which offers opportunities for rent-

seeking (Gupta et al., 2002) hence leading to the neglect of goods and services needed by the poor.

Second, bureaucratic corruption which is regarded as a lower form of corruption because it usually emanates from the lower levels of the bureaucracy that interacts with the general public, and sometimes results from the relationship between the political elites and bureaucrats (Gupta et al., 2001). In this context, corrupt bureaucrats are induced in the form of bribe to provide services or speedup bureaucratic procedures (Mauro, 1995). There is also the tendency for bureaucrats to extract bribes to execute tasks assigned to them by the political class or to carry out tasks that were not delegated to them.

Lastly, legislative corruption which is a form of corruption associated with the voting procedures of the legislators. Individuals and lobby groups can bribe the legislators to enact laws that are profitable or favourable to pursue and capture economic rents associated with their business activities.

These three forms of corruption can only be different by the ways in which decisions of the individuals can be influenced by corrupt practices, but the end result of corruption could be the same across the three forms, which is a misallocation of resources and inefficiencies that would eventually lead to poor economic performance. Hence, the definition of corruption envisaged by this thesis is broad enough to encompass these three forms of corruption. However, the definition chosen has been subjected to criticism by some scholars. Shaxson (2007) is of the view that this definition is too narrow, while Knack (2007) states that one cannot assign one definition to the work of TI because TI's indexes by definition are composite indexes, hence it consists of various definitions from the data which they are compiled from. Thus, these shortcomings attributed to the definition chosen, and the discussions above have indicated the complexity of corruption is not only present in how it is

viewed but also in the fundamental ways in which it has been defined.

Furthermore, to correctly understand the concept of corruption, the concept of rent-seeking must be understood, which refers to the pursuit of economic rents. A rent has been defined as "spending money in socially unproductive efforts to acquire, maintain, or exercise monopoly" (Pindyck and Rubinfeld, 2009, p.378). The authors defined rent "as the amount that firms are willing to pay for an input less the minimum amount necessary to obtain it" (Pindyck and Rubinfeld, 2009, p.542). Similarly, Svensson (2005, p.21) defines rent as "the socially costly pursuit of rents, often created by government interventions in the economy". In other words, some level of rent-seeking is inevitable in all types of political systems and all the regions of the world. Rent-seeking usually arises in cases where government policy creates an artificial or contrived rent, such as through licenses or protected monopolies (Weil, 2009), that is, the opportunities for rent-seeking often arise in the public sector. Thus, the ability of the government to artificially create rents through licensing and regulations makes the most common forms of corruption to revolve around it (Treisman, 2000).

These have motivated some studies (e.g., Murphy et al., 1993) to argue that the concept of rent-seeking can be divided into illegal corruption and legal lobbying. It is generally considered that lobbying is targeted at elected politicians and corruption is targeted at bureaucrats who are to enforce policies enacted by the elected politicians. For example, while corruption is often associated with money given to bureaucrats who are enforcers of policies, lobbying is mostly associated with political campaign activities or any other practices aimed to influence the elected politicians who enact laws or policies (Campos and Giovannoni, 2008).

It is also the view of Svensson (2000) that corruption and lobbying can be partially substituted for each other because a firm could switch the rules through lobbying while

through bribery it could bend the rules. If politicians can successfully be lobbied by the firm to change the rules, then the firm does not need to bribe officials to bend them. But if firms can easily bribe the bureaucrats, then it might not engage in lobbying to change the rules since there is the tendency that the outcomes of lobbying will be substantially uncertain.

1.3. Causes of corruption in Sub-Saharan Africa

This subsection aims to provide answers to questions such as: why do politicians and bureaucrats in some countries are more corrupt than their counterparts in other countries? Why corruption is of the uncoordinated and unorganised type in SSA countries? Although, there are many determinants of corruption identified in the literature address these questions, the chapter only explores a set of factors that has been established both theoretically and empirically to be among the most significant determinants of corruption in SSA countries.

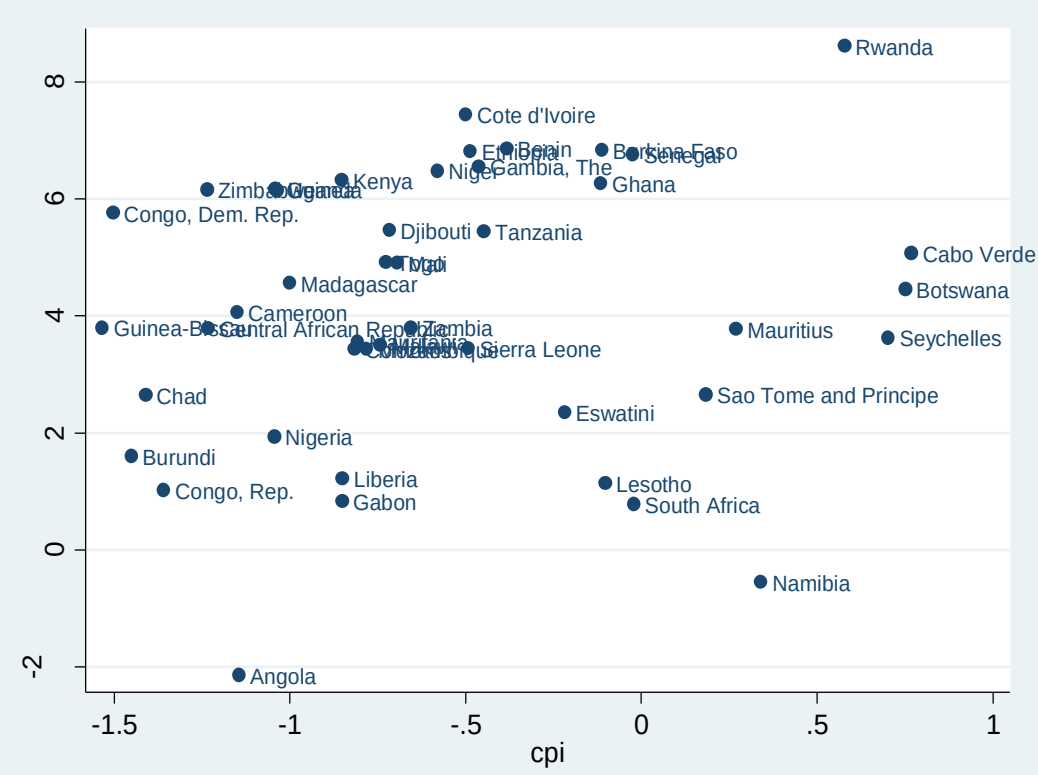
Economic Development

The phenomenon of corruption has been linked to the level of economic development although views on this relationship is conflicting. Shleifer and Vishny (1993), argue that high level of corruption reduces economic development, while Treisman (2000) argue that lower levels of economic development causes corruption. Despite these conflicting views, Mauro (1995) argues that there is a strong negative correlation between GDP per capita and a country's score on corruption perception indexes. The insight is that it is easier for corrupt activities to take place in less developed countries than in developed countries. This is because positive economic performance tends to increase the levels of education, literacy and depersonalized relationships (Treisman, 2000; Tanzi, 2000).

Figure 1.1 is scatterplot of World Bank control of corruption index and the average income growth rate of SSA countries in 2018. The figure shows differences in the growth effect of corruption among SSA countries. For example, some countries such as Angola combine high incidence of corruption and slow economic, others such as Congo Dem. Rep. combine high rates of corruption and high economic growth.

These has led to debates on whether corruption enhances or cripples economic performance. For example, Leff (1964), Bayley (1966) and Huntington (1968) are of the view that that corruption enhances growth for two reasons. First, corruption could be used as a "speed money" to avoid delays due to bureaucratic red tape, hence the "grease the wheels" hypothesis. Second, corruption could be used to incentivise corrupt employees to work harder or put greater work effort. Through these, corruption would facilitate growth or, if the government is observed to be indifferent, hostile to development or have other priorities than growth. Corruption is also noted to be beneficial to investment since it may induce some elements of competition especially when the critical sectors of the economy are being dominated by national monopolies or ineffective enterprises that are supported by government subsidies (Leff, 1964; Huntington, 2006).

Figure 1.1: Corruption and Growth Rates in SSA Countries



Sources: World Bank Development and Governance Indicators Databases

In contrast to the above views, most studies argued that corruption has adverse effects on economic growth. Mauro (1995) argues that weak government institutions constitute a severe obstacle to investment, innovation and entrepreneurship and thus exerts a significant negative impact on growth and thus can be costly to economic development (Keefer and Knack, 1995; Shleifer and Vishny, 1993). Svensson (2005) argues that these performance impacts of corruption are more pronounced in developing countries and due to its pervasive nature, it has led to increased income inequality and poverty (Gupta et al., 1998).

In this regard, some studies argue that income inequality is not only a consequence of corruption but also an important determinant of corruption (e.g., Paldam, 2002; Dreher et al., 2007; Rose-Ackerman, 2008; Treisman, 2000; Buehn and Schneider, 2012).

Political Institutions

Some studies in the corruption literature investigate the impact of corruption in the context of

democracy versus autocracy, and regimes that are development-oriented and neo-patrimonial ones. Aidt el al., (2008) investigated the role of political institutions in determining the relationship between corruption and economic growth. The authors find that, the relationship between two variables as regime specific. For example, in a regime with high quality political accountability, corruption has a substantial negative impact on growth, while in a regime with low quality institutions; corruption has no impact on growth. Mendez and Sepulveda (2006) also argue that the relationship between growth and corruption is quadratic and this relationship depends on the degree of political freedom within a country.

Dreher et al. (2007) find that weak political institutions lead to corruption, and democracy through political competition raises the level of transparency and accountability, which in turn reduces corruption. Similarly, Buehn and Scheider (2012) show how weak governance leads to a higher level of corruption, however, when political competition is promoted, transparency and accountability increase, which in turn reduce corruption. Some studies have attempted to provide a more intricate nature of democracy by examining the effect of corruption in certain features of democracy, rather than focusing on corruption reducing potentials of democracy. Gerring and Thacker (2004), Lederman et al. (2005) and Kunicova (2006) investigated whether parliamentary systems fare better with respect to perceived corruption than presidential systems and they find evidence that parliamentary systems are associated with lower levels of corruption than presidential systems.

Other studies (e.g., Persson et al., 2003) examine the features of the electoral system to determine the relationship between corruption and economic performance. Some authors find that a lower level of corruption is associated with larger voting districts and the larger the number of contestants listed lists the higher the level of corruption. In studies related to SSA

countries,[1] neo-patrimonial type of governance has been strongly associated with corruption because of rent-seeking behaviour by bureaucrats at the highest level of government in neo-patrimonial states (Coolidge and Rose-Ackerman, 2000).

Ethno-linguistic Fractionalization

Nowhere in the world is the effects of ethno-linguistic fragmentation so pronounced than in SSA countries. According to Easterly and Levine (1997), the 15 most heterogeneous countries in the world are in Africa.[2] Since these partitions were not generally guided by the need to safeguard the identities of the indigenous states or ethnic groups, it has resulted in splitting of ethnic groups across different borders. This has further exacerbated the pre-existing levels of ethnic and linguistic diversity. This is important because if societies do not internalize the effects of their actions on other groups (Shleifer and Vishny, 1993) they would attempt to obtain as much rent as possible when they come into power or attempt to block other competing ethnic groups from having access and may give rise to corruption.

Views in the literature on the relation between ethno-linguistic fragmentation and corruption are varied. Mauro (1995) has demonstrated an empirical association between ethno-linguistic fragmentation and high level of corruption, while Rose-Ackerman (1999) argues that corruption is high in countries with higher ethno-linguistic fragmentation and lower corruption is associated with homogeneous societies (Tanzi, 1998). However, Treisman (2000) argues that ethno-linguistic fragmentation can be an indirect cause of corruption; hence, corruption may decrease economic development indirectly through ethno-linguistic fragmentation.

[1] This is another strand of the literature was originated by French scholars in the 1980s and examine corruption by focusing on the informal aspect of power, hence the so-called "politics of the belly" or "neo-patrimonial" approach. The approach shows how African politics is unique from the rest of the world, where governance is associated with political relations, clientelism and political corruption (Hope and Chikulo, 2000; Bayart, 1993; and Bratton and van de Walle, 1994).

[2] The borders of the continent were determined through series of negotiations between the European powers based on the Berlin conference of 1884 – 1885.

Foreign Aid

The exact impact of aid on the quality of governance is difficult to assess even though SSA countries are among the largest recipients of foreign aid both bilaterally and multilaterally. According to OECD (2005a), one-third of the aid disbursed in 2005 went to SSA countries. Notwithstanding, when aid is used to raise public service wages or attract better human capital, it would help reduce corruption or demands for bribes (Van Rijckeghem and Weder, 2001). Importantly, if aid is channelled towards legal and judicial reforms as well as the public service reforms, it would be effective in curbing corruption. However, according to Brautigam (2000) foreign aid could also lead to misallocation of labour in the recipient country because civil servants would be attracted to work with donor agencies, where the wage level is higher than those offered by the recipient's public service.

Findings on the impact of foreign aid on corruption seem ambiguous in the literature. Alesina and Weder (2005) find weak evidence that foreign aid causes corruption. Svensson (2000), by examining the relationship between corruption and concessional assistance, finds evidence that foreign aid causes corruption particularly in countries that are more likely to suffer from competing social groups. Although Knack (2007) finds evidence that aid erodes bureaucratic quality and the rule of law, the study finds no significant relation between aid and corruption. However, Tavares (2003) finds evidence that show foreign aid reduces corruption.

Colonial Influence

Some studies examine how colonial heritage may influence corruption in SSA countries.[3] These studies were motivated by the view that the main factor that drove colonialism in Africa was the need to conquer and exploit natural resources. Acemoglu et al. (2001) argue that the institutional legacy left in Africa by the European colonisers are "extractive" because the colonialists did not introduce institutions that protect private property or checks and

[3] For example, Young (1995, p.24) notes that "overall, colonial legacy cast its shadow over the emergent African state to a degree unique among major world regions".

balances against government expropriation. According to the authors, the main purpose of the creation of extractive states was the need to transfer natural resources to the colonising countries with minimum amount of investment.

This has motivated some studies to conclude that former British colonies in SSA are less corrupt than the French, Spanish, Portuguese and Belgian former colonies (e.g., Swamy et al., 2001; Treisman, 2000; Sera, 2006). These studies point to the tradition of free press, strong legal institutions, the importance of education and the impartiality of the British civil service as factors. Hence, one may suggest that former colonial masters have left an institutional legacy that has continued to shape the subsequent form and extent of corruption in their former colonies.

Level of Education

Studies on the role of education as a determinant of corruption are conflicting in the literature. Ehrlich and Lui (1999) argue that corruption and education jointly influence economic development while individually they do not have an impact. Dreher et al. (2007) find low school enrolment leads to increase in corruption, while Buehn and Schneider (2012) find no such evidence. Barro (2000) and Li et al. (1998) find similar results that more years of schooling have an income equalizing effect thus decrease in corruption. Mauro (1997b) looked at the issue indirectly through the fraction of government spending on education and finds a negative correlation education and corruption. In other words, the lower the government expenditure on education, the less a country's population becomes educated but the effect this has on corruption is not well established. Therefore, corruption tends to reduce the quality of education and health care, hence decreasing economic development through reducing human capital development.

Public Sector Wages

Some countries may be corrupt due to low public service wages relative to the minimum

required to have a "decent" living. As a result, most anti-corruption measures advocated to developing countries by multilateral donor agencies in mid-1990s, involved ambitious efforts to overhaul the public service along Weberian lines (Treisman, 2000). Gould (1980) in a study on Zaire finds that, due to the low public service wages, which is below the poverty line relative to the earnings of the political elites, there is a widespread perception among the general public that civil servants must indulge in corruption to survive.

Notwithstanding, theoretical works by Bestley and McLaren (1993), Flatters and Mcleod (1995), and Becker and Stigler (1974) have shown that it is prohibitively expensive to have less corrupt civil service because only paying higher wages would incentivise public servants not to indulge in corruption. In an empirical study Van Rijckehem and Weder (2001) show, a large increased in the levels of wages in public service is needed to eliminate corruption. In other words, incentivising public sector workers by increasing wage dispersion and setting formal recruitment and promotion criteria will reduce corruption in the public sector.

Legal System

The type of legal system operated by country has been identified as a determinant of corruption. This is because protection of private property especially from corrupt government officials may vary depending on the effectiveness of the legal systems, formulation and original intent of the laws made by countries. La Porta et al. (1999) argue that common law systems differ from civil law systems. An example of this is an attempt by the Parliament and the autocracy in England in the 17^{th} century to limit the power of the sovereign from regulating and expropriating their wealth. Thus, a common law system can be argued to have the intention of limiting the powers of the state rather than strengthening it. The difference of civil law from common law is that it was formulated mainly to find solutions to a dispute, rather than following a set of procedures. Therefore, common law systems tend to improve several aspect of government performances, and this includes reducing corruption (La Porta

et al., 1999).

Religious Beliefs

Most countries in SSA are regarded as deeply religious and this has shaped cultural attitudes towards corruption. Corrupt activities could be influenced by religion through the dimensions of hierarchy and influence between the church and the state. La Porta et al. (1999) identify Catholic, Islam and Greek Orthodox beliefs as hierarchical in nature, and that countries associated with these religions tend to exhibit weak level of governance compared to largely Protestant countries (La Porta et al., 1999). Hence, it is possible that countries with greater religious hierarchy have corrupt activities transposed to other areas, compared to countries that are associated with egalitarian beliefs, such as Protestantism (Lipset and Lenz, 2000).

A conflicting study by Treisman (2000) finds a strong negative association between corruption and Protestantism. Specifically, the author found a highly significant negative impact of the percentage of Protestants in the total population on the perceived levels of corruption. This evidence is corroborated by other studies such as, Lipset and Lenz (2000), Sandholtz and Koetzle (2000), Paldam (2001), Gerring and Thacker (2004) and Serra (2006). The conclusion one can reach from this, is that the more societies are associated with egalitarian beliefs, the less would be the negative effects of corruption on economic development.

Table 1. 1 Summary of literature review on Causes of Corruption

Study	**Transmission Channel**	**Policy Impacts and Relevance**
Mauro (1995)	*Investment*	*Improving integrity and efficiency of bureaucracy can boost investment rate thereby increasing growth*
Knack and Keefer (1997)	*Weak institutions*	*institutions that protect property rights are crucial for economic growth*

Sachs and Warner (2001)	*Natural resources*	*Diversifying the economy away from natural resources would boost economic growth*
Li et al. (2000)	*come distribution*	*Reducing corruption will reduce income inequality*
Mo (2001)	*Investments, government expenditure, political instability and human capital*	*Reducing institutional inefficiency, such as bureaucratic red tape and weak legislative and judicial systems would increase private investment, reduce political instability and boost human capita*
Gyimah-Brempong (2002)	*Investment and income inequality*	*institutional reforms by African countries would expand employment opportunities and thus improve income distribution and in flow of private investment*
UNDP (1997)	*Weak governance*	*To enhance economic growth, anticorruption laws should be enforced, institutional checks and balances and economic reforms programmes should be implemented*
Wei (2000)	*foreign direct investment*	*A decrease in either the tax rate on multinational firms or the corruption level developing governments would boost inward foreign direct investment.*
Tanzi (1998)	*International trade and economic reforms*	*Make regulations transparent and nondiscretionary. Increase public sector pay and impose penalties corrupt public servants.*
Gupta et al. (2001)	*Health and education sectors*	*Combating corruption in both health and education sectors would decrease child and infant mortality rates, percent of low-birthweight rates, and primary school dropout rates.*

1.4. Corruption as a motivation for reforms

It is more than three decades since developing countries started implementing Electricity Sector Reforms (ESR). The implementations of these market-oriented reforms were in response to a combination of political, ideological, technological and economic factors that aimed at dismantling the dominance of state-owned utilities and encourage the private sector participation (Jamasb, 2016). Efficiency improvements post reforms implementation in some pioneer countries like Chile, UK and other OECD countries, led to the emergence of the textbook/standard electricity reform model. The reform model essentially calls for the enactment of reform legislation, unbundling and commercialization of the vertically integrated state-owned utilities, privatization of the unbundled parts and attracting other forms of private sector investments, and the creation of independent regulators to oversee and

regulate the activities of all players in the sector.

Following the success of these pioneer countries, reforms were implemented in SSA countries to improve the poor performance of state-owned electricity utilities, remove the burden of price subsidies, mobilise the needed investments to maintain network infrastructures, expand electricity services to the millions without access, and improve the reliability of service in areas where services has been provided. Apart from these and other motivators of reforms in the region, there is another important, but less explored, factor that drove ESR in SSA countries: corruption. The potentials of ESR to mitigate the crippling effects of corruption on electricity sector performance because reforms were underpinned by an anti-corruption agenda (World Bank, 2000).

Although, studies such as Besant-Jones (2006) argue that outcomes of reforms in developing countries should be assessed based on improvements in quality of service provision, expansion services to those without access, and improved government's fiscal position, a lower level of corruption in the sector is also an expected outcome (Estache et al., 2009). This is because, different aspects of the reform model have different corruption reducing effects. For instance, unbundling of the vertically integrated state-owned utilities would help identify all sources of inefficiency including corruption, competition among the unbundled units give consumers freedom of choice and escape from corruption associated with the state-owned monopolist. Similarly, privatised firms as residual claimants have incentives to close all sources of inefficiencies including those related to corruption and regulators safeguard smaller firms from dominant firms, collusions among firms, safeguard firms from government corruption and consumers from exploitations. However, despite nearly three decades of reforms in SSA countries, there has been no detailed evaluation and analysis on this important motivator of reforms in the region.

1.5. Outline of the thesis and research contributions

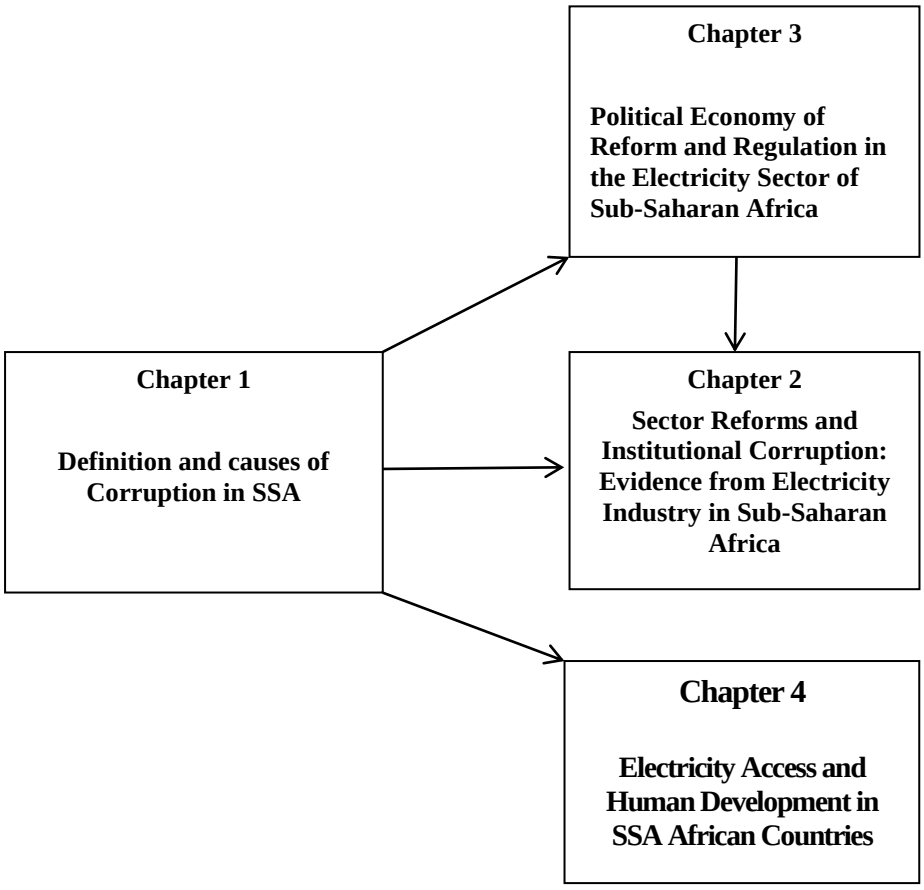
The main aim of this thesis is to analyse the impact of corruption on electricity sector performance and evaluate how reform policies mitigate this performance effects of corruption. In order to achieve this, the chapter started by defining corruption and identified some causes of corruption that are relevant to SSA countries. These identified causes gave insights on how the relationship between corruption and economic development can operate through various channels especially through the electricity sector.

This observation leads us to Chapter 2 which examines how corruption affects economic development and electricity sector performance, and how reform policies – creation of independent regulatory agencies and private sector participation – influence this relationship. The findings show that corruption can significantly reduce technical efficiency of the sector and constrain the efforts to increase access to electricity and national income. However, these performance effects are reduced where independent regulatory agencies are established, and privatisation is implemented. The findings suggest that well-designed reforms not only boost the performance of the sector directly, but also indirectly reduce the negative effects of macro level institutional deficiencies such as corruption on micro and macro performance.

Chapter 3 extends the findings of the previous chapter by examining how politicians, who by advancing the ideologies of their parties, intrude into regulatory functions thereby affecting electricity sector performance. The chapter uses data on 45 SSA countries with different ideological orientations and find negative impact from independent regulatory agencies on installed capacity in countries with left-wing governments while in countries with right-wing governments there is a positive effect on capacity. Also, the results show negative impact on electricity access when regulators are established in countries with left-wing governments, while there are no significant impact for the right-wing governments.

Chapter 4 analyses the expansion of access in SSA countries in terms of human development post reforms and other policies implemented to increase access to electricity. The results show that expansion of electricity access has positively and significantly improved human development in SSA countries. Similarly, findings were established on the three individual components of human development (life expectancy, GDP per capita, and education). The results indicate the importance of electricity in enhancing human development as it has potentials to eliminate of energy poverty usually associated with SSA countries and thus eliminate poverty in the region sustainably.

Figure 2.2: Flowchart of the thesis' chapters



The three independent, but related stand-alone research chapters are depicted in Figure 1.1. The three chapters have some characteristics and similarities. First, the three chapters are on SSA countries. Second, the analysis in the three chapters are based on a dynamic panel data

approach. Lastly, the chapters are concerned with policy implications of ESR implementation on socio-economic development of SSA countries.

There are some important contributions of the thesis to both policy and research. First, it provides insights on how corruption and political interferences could weaken institutions and regulatory frameworks necessary to encourage private investments to finance the construction of critical infrastructures in SSA countries and the implication of this on the socio-economic development of the region. In this regard, the thesis shows how implementation of electricity reforms in SSA countries have, to some extent, addressed the root cause of inefficiency, low access and low generation capacities of utilities and thus have contributed to the socio-economic development of the region.

Second, the research show where and how corruption is hurting the economic development of SSA countries. In this regard, this contributes to policy by highlighting the importance of designing appropriate policies that would reduce uncertainties surrounding issues related to market access, tariffs, and revenues but also help improve the overall governance of the sector thereby tackling one of the numerous challenges such as energy poverty faced by countries of the region.

The thesis fills a gap in the literature by specifically focusing on the effects of corruption on one important indicator of economic development of SSA countries, i.e., electricity sector reform performance. The research, therefore, contributes to the literature by moving forward the current scholarly investigation on the effects of Illicit Financial Flows (IFFs) on economic development of SSA countries (AU/ECA, 2014). Similarly, it contributes to the institutional aspect of power sector reforms that emphasizes the importance of corruption (Estache et al., 2009) and adds to a broader literature that studies the impacts of political corruption and rent-

seeking on economic development by using indirect methods[4] (Aidt el al., 2008; and Fisman and Svensson, 2007).

[4] Through assessing its effects on the operation and regulation of electricity networks and human development.

Chapter 2: Sector Reforms and Institutional Corruption: Evidence from Electricity Industry in Sub-Saharan Africa

Abstract

In order to reduce the influence of corruption on electricity sector performance, most SSA countries have implemented electricity sector reforms. However, after nearly two and half decades of reforms, there is no evidence whether the reforms have mitigated corruption. Neither is there evidence of performance improvement of the reforms in terms of technical, economic or welfare impact. This chapter aims to fill this gap. The chapter uses a dynamic panel estimator with a novel panel data of 47 SSA countries from 2002 to 2013. The chapter analyse the impact of corruption and two key aspects of electricity reforms – creations of independent regulatory agencies and private sector participation – on three key performance indicators: technical efficiency, access to electricity and income. The result show that corruption can significantly reduce technical efficiency of the sector and constrain the efforts to increase access to electricity and national income. The adverse effects are reduced where independent regulatory agencies are established and privatisation is implemented. These findings suggest that well-designed reforms not only boost the performance of the sector directly, but also indirectly reduce the negative effects of macro level institutional deficiencies such as corruption on micro and macro performance indicators.

Keywords: electricity sector reform; corruption; Sub-Saharan Africa; panel data; dynamic GMM.

JEL classification: Q48, D02, K23, D73.

2.1. Introduction

Over the past two decades, a body of literature has emerged that establishes the various transmission channels through which corruption can constrain economic development. For example, corruption, defined as the "abuse of entrusted power for private gain",[5] is found to have corrosive effects on economic development through increasing transaction costs and uncertainty (Murphy et al., 1991), inefficient investments (Mauro, 1995; Shleifer and Vishny, 1993), reduced human capital development (Reinikka and Svensson, 2005), and misallocation of resources (Rose-Ackerman, 1999).

Recently, attention has shifted to another important but less explored micro-level channel, i.e., the operation and regulation of electricity sectors particularly in developing countries (Wren-Lewis, 2015; Estache et al., 2009; Dal Bó, 2006; Bergara et al., 1998). The preponderance of evidence from this strand of literature suggests that corruption can cripple economic development by inhibiting the performance of the electricity sector. For instance, corruption reduces labour productivity (Wren-Lewis, 2015; Dal Bó, 2006), increases transmission and distribution losses and constrains the efforts to increase access to electricity services (see Estache et al., 2009).

The impact of corruption on electricity sector performance is particularly relevant in SSA, where welfare improvements can be linked to widespread corruption (Gyimah-Brempong and de Camacho, 2006). Despite the difficulty of measuring corruption, the Corruption Perception Index (CPI) produced by Transparency International (TI, 2013) shows that eight of the twenty most corrupt countries in the world are in SSA and the only region with more than two countries in this group. Thus, in weak institutional settings, major undertakings such as the construction of large hydroelectric dams, government intervention, monopolistic characteristics of the sector, absence of competition and substantial revenues from the sales

[5] See Kaufmann and Siegelbaum (1997) for discussions on this definition.

of electricity make the sector vulnerable to corruption (Bosshard, 2005; World Bank, 2009; Reinikka and Svensson, 2005).

The above factors could be partly blamed for turning the electricity sectors in SSA countries into sources of corruption and cronyism (Patterson, 1999) and the concentration of electricity services to urban areas whilst rural areas remained unconnected or underserved (Byrne and Mun, 2003). This is referred to as 'electricity poverty' and is widespread in the region.[6] In order to improve efficiency and reduce corruption, many SSA countries have implemented ESR (Eberhard et al., 2016). Such reforms, also referred to as the 'standard electricity reform model' and often prescribed to developing countries by multilateral development organisations, were first implemented in OECD countries such as Chile, Norway and the UK in the 1980s and 1990s.

The experiences of these pioneer countries supported the notion that effective implementation of ESR would not only enhance technical efficiency of the sector but would also translate the efficiency gains into social welfare and economic growth (Sen et al., 2018). Moreover, according to the World Bank (2000), as part of wider economic liberalisation, deregulation and demonopolisation policies, ESR policies were further underpinned by anticorruption agendas. Thus, reforms not only promised improved efficiency and access to reliable and affordable services, they also promised reduction in corruption in the sector (Estache et al., 2009) and the wider economy (World Bank, 2000).

Despite the anticipated positive outcomes from implementation of the reforms, there are widespread perceptions that reforms have hurt the poor through increased tariffs, stronger enforcement of bills collection (Scott and Seth, 2013) and unemployment, while benefitting

[6] The majority of the estimated 500 million people who lack access to clean and affordable electricity in the region are poor and rely on traditional biomass – wood, agricultural residues and dung – for cooking and heating needs (IEA, 2014).

the powerful and wealthy notably through corruption (Auriol and Blanc, 2009). As a result, the reforms often lacked social legitimacy, and this usually manifests through increases in electricity theft and vandalism (Williams and Ghanadan, 2006). Moreover, as Estache et al. (2009) have noted, large numbers of people believe that corruption still remains a problem in the sector. However, despite the anecdotes that connect corruption to sector performance after the reform efforts, there is a lack of empirical evidence on whether the electricity sector reforms in SSA region have mitigated or exacerbated the effect of corruption in the electricity sector.

Previous empirical studies have shown the relevance of corruption as a driver of ESR in developing countries, but they either focus on labour efficiency in electricity distribution utilities (e.g., Wren-Lewis, 2015; Dal Bó and Rossi, 2007) or on different sectors (e.g., Estache et al., 2009). Moreover, the former two studies focused on Latin American countries while the latter study includes countries from different developing regions. Therefore, to my knowledge, this is the first empirical study to assess the electricity reforms in SSA countries and among the few studies that examine the interactions between country level institutions and micro-level electricity reform steps (e.g., Wren-Lewis, 2015; Estache et al., 2009). Most studies of this strand of literature tend to focus on specific aspects of the textbook reform model or on specific countries without explicitly accounting for the role of institutions apart from those earlier mentioned.

The chapter addresses the gap in the literature and contributes to better understanding of the institutional aspect of electricity sector reforms (e.g., Dorman, 2014; Chang and Berdiev, 2011; Nepal and Jamasb, 2012a; Cubbin and Stern, 2006; Erdogdu, 2013) and the political economy literature of regulatory agencies (e.g., Pitlik, 2007; Potrafke, 2010; Scott and Seth, 2013). This study indirectly contributes to the literature on obsolescing bargaining (Vernon,

1971) since political corruption entails government commitment to honour the terms of electricity reforms and particularly the privatisation of state assets, could be doubtful. Thus, the findings provide further insights into why investments in the SSA electricity markets tend to be more concentrated in the generation segment than in the distribution utilities since the former is more susceptible to corruption.

The remainder of this chapter is as follows. Section 2.2 reviews the nearly three decades of ESR in SSA countries and discusses how each of the key steps of the reform model may mitigate the adverse effects of corruption on the performance of the electricity reforms. Section 2.3 presents three research hypotheses related to key performance aspects of reforms to be tested. Section 2.4 presents the empirical methodology and the data used in the study. Section 2.5 presents and discusses the results. Section 2.6 concludes the chapter.

2.2. Electricity Sector Reforms in Sub-Saharan Africa

Historically, the generation, supply and marketing of electricity in most SSA countries, as in many other regions of the world, were dominated by vertically integrated state-owned utilities (Clark et al., 2005). These arrangements were partly regarded as primary functions of the state, such as, the high fixed costs of large plants, the desire of governments to enhance welfare, national security concerns, social equity objectives (World Bank, 1993) and ideological reasons (Erdogdu, 2013). The state-ownership was reinforced by the idea that permitting more than one firm would increase costs while this resulted in higher investments by public utilities relative to private utilities (USAID, 2005). The 1980s and 1990s saw SSA countries unable to sustain investments in the sector. Decades of government investments had not produced the anticipated results as services and subsidies remained concentrated in urban areas, nor were there improvements in quality and reliability of service.

The first electricity reform took place in Chile in 1983, and then in OECD countries such as Norway and United Kingdom. From these experiences emerged the theory and practice of the 'standard textbook reform model'. It was believed that reforms would reduce the dominance of the state through creation of Independent Regulatory Agencies (IRAs) and private sector participation (Jamasb et al., 2016). The expected outcomes were the enhancement of economic and technical efficiency of utilities and the transfer of efficiency gains to consumers in the form of improved access to affordable and reliable electricity (Nepal and Jamasb, 2012b; Estache et al., 2009).

In SSA, macroeconomic conditions such as the deteriorating international business climate, fiscal constraints faced by governments, structural adjustment programmes (Jamasb, 2006) compelled the countries to undertake structural and institutional reforms of their sectors. Many of the arguments that supported state ownership of utilities disappeared by the 1980s as the economies of scale of vertically integrated utilities had been exhausted (Joskow, 2006; Gilbert et al., 1996), therefore state-ownership came to be seen as a hindrance to adoption of new technologies by the private sector (Downing et al., 2006). The reforms in SSA were triggered by investment shortfalls and concerns that monopolisation of the sector by state-owned utilities were wasteful and inefficient (Victor, 2005).

The standard reform model calls for the unbundling of state-owned electricity utilities vertically (generation, transmission, distribution and retailing) and horizontally (generation and retailing). The unbundled parts amenable to competition would then be sold to the private sector and an independent sector regulator would supervise and regulate the natural monopoly parts of the sector (Victor and Heller, 2007). The electricity sector specific and external factors that triggered ESR varied in developed and developing countries (Jamasb et al., 2016). In addition, the extent and outcome of reforms have differed in these countries

(Nepal, 2013). The reforms in developed countries were undertaken in the context of excess capacity and stable institutions aimed at improving economic and financial performance of technically reliable systems, encourage interregional trade, transfer investment risks to the private sector, offer consumer choice, and reduce overinvestment (Jamasb et al., 2014; Erdogdu, 2013). Conversely, ESR in the developing countries were implemented within a context of poor technical and financial performances of state-owned utilities, weak institutional setting, inability of utilities and governments to mobilise sufficient investments to provide access, low tariffs and poor service quality (Jamasb et al., 2005).

However, the suitability of the standard reform model for developing countries has been questioned as it has usually resulted in higher prices, loss of employment, unreliable service, and concentration of service to profitable areas since private firms did not have incentives to extend the service to poor people (Transnational Institute, 2002; Victor, 2005). Thus, in the unprofitable segments there has been an absence of service provision (Auriol and Picard, 2006). The poor access rates in SSA relative to other developing regions may be partly attributed to this lack of incentives. For example, although between 2000 and 2014, there was some progress in increasing access to electricity in all developing regions of the world; access deficit is overwhelmingly concentrated in SSA region, as progress has fallen consistently short of population growth. The poor outcomes have led the reform critics to argue that the state should take the responsibility for such investments (Victor, 2005).

Moreover, the experiences of ESR around the world have shown the difficulty of creating efficient electricity sectors underpinned by genuine competitive markets that show significant potentials to benefit consumers through reliable service, low tariffs, and choice of alternative sources (IEA, 2014). As a result, the reform experience in SSA has lagged behind the anticipated outcomes of the standard reform model and has led to extensive political backlash

against the reforms. Higher electricity prices have been an obvious source of political resistance in many countries, especially for groups that have become accustomed to paying near nothing for electricity services (Victor, 2005) and this resistance was further reinforced by the awareness that elections can be won or lost because of electricity prices (UNDP and World Bank, 2005).

Table 2. 1 Implementations of Electricity Sector Reforms in SSA countries

No ESR Initiated	Vertically integrated w. priv.*	Vertically integrated w. IRA only	Vertically integrated w. IRA and priv.	Unbundled w. IRA and priv.	Unbundled w. IRA only
Benin Burundi Central African Rep. Djibouti Equatorial Guinea Eritrea Seychelles Congo Dem. Rep. Guinea	Botswana Chad Madagascar Mauritius Liberia Guinea Bissau Comoros Congo, Rep.	Mauritania Niger Swaziland	Angola Burkina Faso Cape Verde Cameroon Côte d'Ivoire Ethiopia Gabon Gambia Malawi Mali Mozambique Namibia Lesotho Rwanda São Tomé & Príncipe Senegal South Africa Tanzania Togo Zambia	Ghana Kenya** Nigeria Uganda Zimbabwe**	Sudan

* All forms of private participation excluding management contracts, lease contracts and concession.
** Kenya and Zimbabwe have only undertaken partial unbundling.
*** Somalia and South Sudan are not included in the analysis. The former due to the lack of data. The latter country gained independence from (North) Sudan in 2011 and the data covers until 2013.

Sources: Eberhard et al. (2016) and World Bank Infrastructure Database (2017).

However, the difficulties of ESR in developing economies have not deterred SSA countries from implementing some aspects of the textbook reform model. Twenty-four of the countries in the region have enacted ESR law, three-quarter have attracted private participation, nearly all have corporatized their utilities, two-thirds have set-up regulatory bodies, and more than a third have Independent Power Producers (IPPs) in place (Eberhard et al., 2016). Table 2.1

summarises the reform efforts in the SSA countries studied here.

2.3. Literature on Corruption and Sector Reform

Corruption and Corporatization/Commercialization

Although independent and incorporated under the same laws governing private corporations, the state retains ownership of corporatized utilities and in some cases runs them through appointed independent board of directors. Whether managed by an appointed board of directors or private contractors, corporatizations of utilities were mainly aimed at reducing the inefficiencies induced by government interference in their operations, facilitate the entry of private capital and move utilities toward cost-recovery in pricing through improved metering, billing and collection (Eberhard and Gratwick, 2011).

Corporatized utilities have achieved modest performance improvements especially those operated by management contractors.[7] Positive outcomes such as improvements in bill collections and reductions in system losses in almost all SSA with management contractors, made international aid agencies involved in most management contracts, to regard them as a first step towards comprehensive reforms. However, contracting out to private sector has been difficult and contentious in some countries.

For example, most governments were unwilling to honour their financial obligations needed to expand capacities, reject tariff hikes (e.g., in Senegal), unwilling to compel government agencies to pay their bills, forbidding utilities from reducing the workforce or disconnecting delinquent consumers (Nellis, 2005). Stakeholders removed from management positions or employees laid off criticised such contracts especially where large fees were paid to management contractors (Eberhard and Gratwick, 2011). The large payouts were argued not to be commensurate with the modest improvements in the finances of utilities. This helped

[7] See Appendix I-1: Table A1 for types, project names and status of management contracts in the countries of our sample.

galvanise a political backlash against such contracts in the region. Moreover, many regulators failed to capture the efficiency gains and competition from management contractors (Nellis, 2005). As a result, management contracts were viewed as unsustainable. Of 16 such contracts in SSA, 4 were cancelled before their expiration dates, 12 were allowed to expire after their initial terms, and only in Liberia and Lesotho there are active contracts. Eberhard and Gratwick (2011). Meanwhile, Gabon and Mali have adopted further reforms.

The eventual disengagement of management contractors from many SSA countries shows that state-owned utilities still dominate the sector. Some governments force utilities to charge electricity prices below the costs of generation and supply, dictate the choice of plants locations or mandate utilities to purchase their energy from state-owned companies (Nellis, 2005) even while lower cost alternatives exist. Thus, it became increasingly difficult to insulate corporatized utilities from corruption usually associated with state ownership of utilities, which has been a key motivator of reforms in the region.

Corruption, Unbundling and Competition

In order to target the sources of inefficiency such as corruption, reformers have advocated for the introduction of competitive electricity markets after the sector is unbundled vertically and horizontally. Thus, irrespective of ownership status, reformers anticipate that competition between the unbundled segments and generating plants offers a reliable mechanism to reduce energy losses and increase capacity utilisation. The gains are expected to increase access rates, while reducing the cost of service to existing consumers (Zhang et al., 2008). More importantly, unbundling and the subsequent competition entails consumers will have more freedom of choice. This also means that consumers can escape from corruption hitherto associated with government-owned utilities. In SSA, only Nigeria has taken steps towards wholesale competition after unbundling and privatising the generation and distribution

segments (Gratwick et al., 2006).[8] Although, the lack of competition in electricity markets of SSA countries can partly be linked to the difficulties of reforming small systems, the absence of private participation in countries such as Sudan,[9] indicates that governance issues are still at the core of the electricity reform efforts in many countries.

Despite the governance enhancing virtues of competition, experience reveals the difficulties of creating genuine competitive electricity markets even in developed countries which are usually associated with strong institutions. In SSA, the emergence of hybrid electricity markets and the lack of robust anti-competitive laws may explain the absence of competitive electricity markets apart from the TEM in Nigeria and the predominance of private sector largely in the form of IPPs. This is because competitive retail or wholesale electricity markets require sophisticated institutional and financial infrastructures (Eberhard et al., 2016). In order to mitigate investment risk in weak institutional environments, private participants such as IPPs often enter into power purchase agreements with the incumbent off-takers by requiring government guarantees, and inclusion of international arbitration clauses.

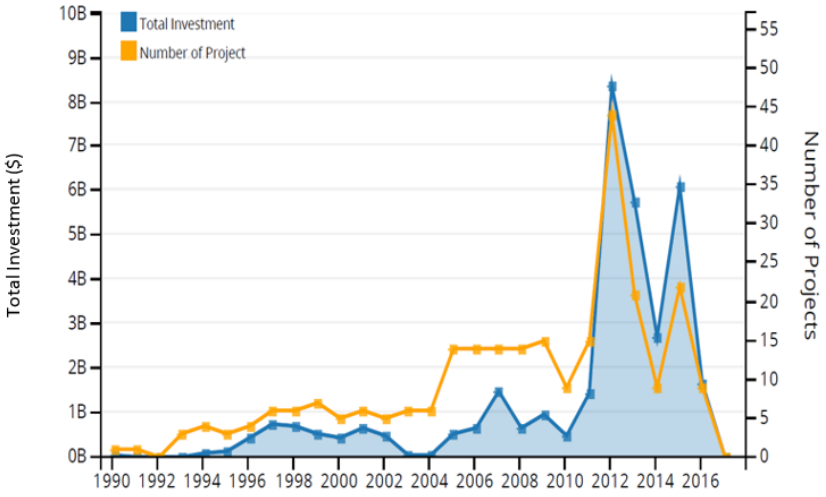
Corruption and Private Sector Participation

Privatisation can improve the performance of the sector through changing the incentive structure. The owners of privatised utilities are the residual claimants of revenue generated by the utility, incentivising them to close inefficiencies including those related to corruption (Olson, 2002). In order to attract investments many reformers advocated privatisation of state-owned utilities to complement private sector participation. The withdrawal of the state from the sector would not only attract private investments and reduce the burden of subsidies on the government from financial overruns of state-owned utilities. Therefore, privatisation can reduce political interference or bureaucratic rigidities in the operations and management

[8] Nigeria established a Transitional Electricity Market (TEM) on February 1, 2015.
[9] Sudan has successfully unbundled its power sector vertically and horizontally and has established an IRA.

of utilities since control rights over these factors would no longer be under the direct control of politicians or civil servants. Despite the increase in private participation after the financial crisis of 2008 in SSA electricity sectors (Figure 2.1)[10], there remains a funding gap for connecting the estimated 500 million people without access to electricity services in SSA (IEA, 2014). ADB (2010) notes that social welfare improvements and productivity in the region, continues to be constrained by the inadequate generation capacity, large technical and commercial losses, limited electrification, unreliable services, and high tariffs.

Figure 3. 1: IPP Investments in SSA Countries, 1990-2016



Source: World Bank PPI Database

Corruption and Independent Regulatory Agencies

Previous studies have linked large energy shortages and investment gaps to historical, financial, social, technical, and economic factors (e.g., Jamasb et al., 2016; Dornan, 2014; Eberhard and Gratwick, 2011). Recently other studies have linked the poor outcomes to the failure of IRAs to improve the institutional conditions of the sector as private investments largely depend on their credibility and independence when investing in countries with weak institutions. Moreover, the emergence of hybrid electricity markets which does not entail total

[10] Close inspection of the World Bank PPI database reveals that more than 90% of the investments that poured into the region's electricity sectors between 1990-2016 were targeted at the generation segment because investors seeking to isolate themselves from corruption prefer selling power to uptakers than to distributors.

withdrawal of the state from the sector (Eberhard et al., 2016),[11] have made the IRAs to struggle to balance the interests of private utilities and the dominant state utilities. Thus, in the context of weak institutional environments of SSA, political expediency tied to the state-owned utilities tends to undermine the independence of the IRAs (Eberhard, 2007). As a result, the regulatory frameworks in these countries are often viewed as compromised. This leads many consumers to assume that the utilities are in collusion with the IRAs and make excessive profits since the regulatory framework has become prone to political capture or a tool for corrupt government officials (Stiglitz, 1998).

According to Eberhard et al. (2016) as of 2014, only 26 of the SSA countries have set up IRAs, while in the remaining countries, energy ministries or departments have the regulatory responsibilities and social and economic objectives. Thus, in the latter group of countries, governments have full regulatory discretion in determining and enforcing tariffs and service standards. Some argue that self-regulation allows corruption to be pervasive in the operations of utilities as most positions in IRAs are usually staffed with friends, family, or political and financial allies of politicians (Estache and Wren-Lewis, 2010). In weak institutional settings, the sector could be influenced by the private agendas of regulators, government, or corruption. Despite the links between weak institutions and performance of utilities, the issue of how corruption and weak governance influence the electricity sector performance post reforms has been neglected in the reform literature and the policies of SSA governments. In order to fill this gap, the chapter analyse whether the implementations of ESR have offset or exacerbated the negative influence of corruption on performance.

2.3.1 Hypotheses

As noted earlier, the main objective of ESR in SSA countries was to improve technical efficiency and translating this into increase electricity access and keep up with economic

[11] This is one of the key factors often suggested for the vulnerability of the electricity sector to corruption.

growth. In order to develop a set of hypotheses to test whether these objectives have been achieved, the chapter rely on the literature on corruption in regulated sectors about how a well-designed regulatory framework may insulate firms from corruption (Levy and Spiller, 1994; Laffont and Tirole, 1986; Estache and Wren-Lewis, 2009). The chapter is further guided by the development literature that states economic performance could be affected indirectly through the impact of corruption on private investment (Wei, 2000). The chapter draw on this literature to identify three indicators of electricity sector performance to assess the corruption reducing potential of ESRs. The variables are placed into three categories each reflecting different dimensions of performance – i.e., technical efficiency, electricity access and economic performance. The first hypothesis focuses on the technical efficiency of electricity sector proxy by Transmission and Distribution (T&D) losses per capita and is as follows:

- *H1: Electricity sector reforms in SSA countries, by offsetting or overcoming the adverse effects of corruption, have improved technical efficiency.*

T&D energy losses are a proxy for technical efficiency because high losses indicate that firms are not only undertaking the needed investments to upgrade and maintain supply networks. It also indicates that firms have operational challenges. Also, vandalism, illegal connections and bribes to workers to avoid electricity bills contribute to high losses and prevents the utilities from undertaking further investments. These factors adversely affect the overall sustainability and productivity of the sector.

Therefore, it is expected that the reforms to enhance investor confidence to undertake investments, improve operations and close sources of inefficiencies leading to efficiency gains. The chapter extends the assessment of impacts of ESR and corruption beyond the sector since one motivation of reforms in SSA was to expand the service to the unelectrified majority. Therefore, the second hypothesis traces the impacts of reforms to their effect on

access to electricity. Previous research has suggested how corruption and clientelistic practices (e.g., Min, 2010) undermine government efforts to extend the service to the poor. Therefore, we expect the loosening of the ties between the government and utilities, through the creations of IRAs and privatisation, to reduce corruption normally related to government operations and regulation of utilities. Moreover, it is expected technical efficiency gains from ESR to translate into expansion of electricity service to those who lack access. Thus, the second hypothesis is as follows:

- *H2: Implementation of ESR by reducing the negative association between corruption and technical efficiency has increased electricity access in SSA countries.*

According to IEA (2014), reforms will boost the economic performance of SSA region by 30% in 2040, not only through private investments but also through governance improvement inside and outside the energy sector. Moreover, World Bank (2000) notes that ESR as part of wider economic liberalisation policies has the anticorruption potential to reduce the negative association between corruption and economic performance. Therefore, due to the positive association between the economy and electricity use on the one hand, and the negative association between corruption and economic performance, it is expected that the reforms to increase income levels. Therefore it is postulated that:

- *H3: Implementations ESR policies in SSA countries have enhanced economic performance of SSA countries by reducing negative association between corruption and economic growth.*

2.4. Methodology and Data

2.4.1. Electricity Sector Performance Estimation

The setup and analysis of the performance equation is influenced by the awareness that ESR in developing countries, as in other sectoral reforms, is not an isolated undertaking but is

closely interlinked with the legal and institutional environments of reforming countries. Therefore, in its simplest form, it is postulated that electricity sector performance (*Y*) depends not only on the vector of reform policies (*REF*) implemented by SSA countries but also on corruption (*cor*) which measures the institutional quality of the countries, and a set of control variables (*X*). Thus, the performance output equation can be expressed as:

$$Y_{it} = \alpha_i + \sum_{p=1}^{2} \beta_{1p} REF_{pit} + \beta_2 cor_{it} + \sum_{p=1}^{2} \beta_{3p} \left(REF_{pit} \cdot cor_{it}\right) +$$

$$\beta_4 ira_{it} priv_{it} + \sum_{q=1}^{Q} \beta_{5q} X_{it} + \beta_6 time + \varepsilon_{it} \quad (1)$$

where *i* and *t* index a country and year, *Y* is the performance output reflecting either of the three performance indicators: technical efficiency (T&D energy losses; *losses*), electricity access (per capita electricity consumption; *access*)[12], and economic performance (GDP per capita; *gdpper*). βs are the parameters to be estimated, the term *time* represents a linear time-trend, which takes into account technological progress. α_i are country-specific effects, included to control for time-invariant unobservables and $\varepsilon_{it} \sim N(0, \sigma^2)$, is the stochastic error term. The vector of reform policies (*REF*) consists of two dummies that reflect the existence of an independent regulatory agency (*ira*)[13] and privatisation (*priv*), a proxy for all forms of private sector participation in electricity sectors[14]. These two reform policies entail whether country *i* at time *t* has succeeded in establishing an independent regulatory agency and opened its doors for private participation. The vector of *Q* control variables (*X*) depends on which of the three performance indicators is used. It captures the demand side of the market and consists of GDP per capita (*gdpper*), total gross electricity generation (*genper*), structure

[12] The data on *access* (electricity consumption per capita) was calculated by total electricity supplied (total production + imports), hence the reason the values for the variable are higher than those of *genper*.

[13] Some of the IRAs in region are multisectoral and all included in the data are active.

[14] Both IRA and PRIV are scored as 0 if countries have not implemented either of the reform steps and 1 if otherwise. Measuring the two reform steps this way does not reflect the degree, amount of investment, extent, or intensity of reforms implemented by the countries. Therefore, the two indicators do not capture the differences in the rate of investments that poured into power markets of SSA countries nor the quality of regulation.

(*struc*) and size (*urban*) of the electricity sector.

In order to capture the corruption reducing effects of ESR on performance, the chapter follows Estache et al. (2009) and Wren-Lewis (2015) and use interaction terms between corruption and the two reform policies (*iraXcor* and *privXcor*). The coefficients of these two interaction terms measure the corruption reducing potential of reforms. An interaction term is also included between the two the reform policies (*iraXpriv*) to assess whether IRAs have constrained or improved the performance of privatised utilities or if private utilities have constraint or reinforced regulatory activity. This is important because, private investors in electricity sectors of developing countries mostly require credible and transparent IRAs to safeguard their investments from expropriation by the state.

Similarly, as noted in the literature on regulatory capture, there is a tendency for regulatory capture in regulated electricity markets due to economic incentives that may push regulators to cater for the interest of the regulated (e.g., Olson, 1965; Dal Bó and Di Tella, 2003; Leaver, 2009). These incentives may arise due to reliance of the regulators on the regulated entity for information they need to do their duties and the desire to hold future well-paid jobs with the regulated since human capital in the sector tends to be industry-specific. Hence, this is the motivation for the inclusion of the third interaction term.

2.4.2. Estimation method

In panel data regressions, the choice of an estimator mostly lies between the Random Effects (RE) or Fixed Effects (FE) estimators to deal with the bias of unobserved heterogeneity. However, both estimators address the bias at the expense of a strong exogeneity assumption. For instance, Equation (1) includes not only country-specific effects that can be correlated with other regressors, but also other theoretically established endogenous regressors (e.g., per capita GDP), thus the orthogonality condition is not likely to be met for a RE or FE estimator

to produce consistent estimates. Jamasb et al. (2005) note that most ESR researchers tend to ignore (implicitly or explicitly) another sources of endogeneity which arises from the possibility of current values of ESR variables and past performance being a function of past condition or performance. The RE and FE estimators do not produce consistent coefficient estimates in the presence of endogenous regressors and dynamics, and thus it is not possible to make inferences based on their estimates.

In order to overcome the methodological concerns, equation (1) is transformed into a dynamic panel specification where lagged values of the three indicators of performance, i.e., the alternative dependent variables (technical efficiency, electricity access and per capita GDP) are included as additional regressors. The dynamic performance equation can be expressed as in (2):

$$Y_{it} = \varphi Y_{it-1} + \alpha_i + \sum_{p=1}^{2} \beta_{1p} REF_{pit} + \beta_2 cor_{it} + \sum_{p=1}^{2} \beta_{3p} \left(REF_{pit} \cdot cor_{it}\right) + \beta_4 ira_{it} priv_{it} + \sum_{q=1}^{Q} \beta_{5q} X_{it} + \beta_6 time + \varepsilon_{it} \quad (2)$$

where Y_{it-1} denotes the lagged value of performance, whilst φ is the parameter associated with that variable. Other variables and coefficients are defined as before. As noted, neither the pooled OLS, FE nor RE estimates of φ are consistent in dynamic models when the time span is small (Nickell, 1981). The study could consider using the dynamic panel General Method of Moments (GMM) estimator proposed by Arellano and Bond (1991). This estimator has the potential to produce consistent estimates in the presence of endogeneity of regressors, unobserved country fixed effects and dynamics. This estimator first eliminates the country-specific effects α_i by differencing the model and instrumenting the lagged dependent variable (Y_{it-1}) with lagged levels of this variable (Arellano and Bond, 1991). However, differencing the data removes all time-invariant variables of interest during the estimation.

Moreover, the Difference GMM (Diff-GMM) is noted to perform poorly in the presence of persistent processes since the lagged levels may convey little information on future changes, thus implying the problem of weak instruments and biased estimates (Roodman, 2008).

Arellano and Bover (1995) and Blundell and Bond (1998) developed a System GMM (Sys-GMM) estimator to improve the efficiency of the Diff-GMM estimator. The Sys-GMM estimator solves the endogeneity problem by treating the model as a system of equations in first difference and in levels. The endogenous regressors in the first difference equation are instrumented with lags of their levels, whilst the endogenous regressors in the level equation are instrumented with the lags of their first differences. The consistency of the Sys-GMM estimator depends on the assumption of no serial autocorrelation in the errors and existence of an array of exogenous regressors. The estimator relies on internal instruments contained within the panel itself and therefore eliminates the need for external instruments and it also avoids full specification of the serial correlation and heteroscedasticity properties of the stochastic error term, or any other distributional assumption.

Despite its advantages, the Sys-GMM estimator has limitations especially as it relies on using the lags of both the dependent and independent variables for identification. This would potentially give rise to a problem of weak instruments, which is usually magnified as the number of instrumental variables increases. Although, increasing the instruments' lag length could make them more exogenous, it may also make them weaker. Furthermore, when using panel data estimators such as the Sys-GMM, the bias resulting from errors in regressors may also be magnified (Griliches and Hausman, 1986). In order to reduce the influence of these and other limitations of the estimator on the results, the analysis avoids the instruments counts exceeding the number of countries in the sample or overfitting of the instrumented regressors. Thus, the instrument set is collapsed as recommended by Roodman (2009) and

report the instrument count for each of the estimations.

Obtaining consistent, efficient and unbiased results using the Sys-GMM estimator is contingent on two specification tests; Hansen test for over-identification restrictions and the Arellano and Bond (1991) test for serial correlation (AR) of the disturbances up to the second order. The Hansen test of over-identification restrictions is a joint test of model specification and appropriateness of the instrument vector. Failure to reject the null hypothesis of the test would indicate that the instruments used in estimation are valid and the model has been well specified. The appropriate check of the Arellano and Bond (1991) test for serial correlation (AR) relates only to the absence of second-order serial correlation (AR2) since the first differencing induces first serial correlation in the transformed errors.

2.4.3. Data

The econometric analysis is based on annual country-specific observations from 47 SSA countries from 2002 to 2013. The selection of countries and period are determined by data availability. Since the main focus of the chapter is on the influence of IRAs and privatisation on corruption, the limited reforms implemented so far in the region would not permit us to assess the impacts of ESR and corruption before 2002. Similarly, the final year 2013, represents the last year for which data are available on electricity consumption per capita and T&D losses at the time when the analyses was conducted. Also, there is no complete data for all the years and countries. Therefore, as the analyses being conducted with different performance indicators the sample size also changes.[15] Table 2.1 shows all the countries included in the analysis[16].

[15] The different sample sizes are reported at the bottom of the estimation results tables in the next section.
[16] For comprehensive definition and measurement of some the variables, check data section in chapter three.

The data for the control variables *urban* and *genper*[17] were obtained from the World Bank Development Indicators and the U.S. EIA respectively. Data for *struc*[18] was obtained from World Bank Development Indicators Database and updated with data from African Development Bank Energy Utilities Database, included in the Africa Infrastructure Knowledge Program. Using these data, the chapter follow Jamasb et al. (2004) to create an index of binary numbers 1 and 0 to indicate whether a country has unbundled its electricity sector. *urban* is a proxy for the size of electricity markets and is measured as the percentage of total population that resides in urban areas. In addition, the data on total household electricity consumption (*hols*) was obtained from the United Nation's Energy Statistics Database.

Table 2. 2: Summary Statistics

Variables Names	Labels	Unit	Obs.	Mean	Std. Dev.	Min.	Max.
Electricity Gen., Per Capita	*genper*	kWh per capita	562	435	880	8	5,306
Regulator	*ira*	Dummy	564	0.49	0.50	0	1
Privatisation	*priv*	Dummy	564	0.58	0.49	0	1
Corruption	*cor*	Index	564	-0.60	0.58	-1.71	1.25
Urbanisation	*urban*	%	562	38.49	16.27	8.68	86.66
Elect. Consumption, Per Capita	*access*	kWh per capita	562	628	1,467	7	10,566
Household Elect. Consumption	*hols*	Million kWh	528	1,755	5,806	4	41,173
Export	*export*	%	528	35.11	22.38	4.43	122.26*
Industrialization	*ind*	%	522	26.24	14.30	3.33	84.28
T&D Losses	*losses*	%	271	20.52	14.36	2.93	86.75
GDP, Per Capita	*gdpper*	2010 US$	562	1,792	2,404	194	12,634
Population Density	*popden*	Inhab./km^2	562	86.63	112.45	2.38	620
Structure	*struc*	Dummy	564	0.09	0.29	0	1

Note: *genper*, *access*, *hols*, *gdpper* and *popden* were log-transformed prior to estimation
* Equatorial Guinea is a notable exception with exports being larger than GDP

[17] The variable does not include data from isolated systems or self-generated electricity which are quite prevalent in the region.
[18] The variable refers only to legal unbundling of the hitherto vertically integrated state-owned utilities.

Finally, in order to test the robustness of the results when the three additional explanatory variables are included - share of industrial output (*ind*), trade openness (*export*), and population density (*popden*) – are included in the performance equations in alternative estimations.[19] The data for these variables were obtained from World Bank Development Indicators Database.

2.5. Results

This section presents the results of the three performance dimensions of electricity (technical, welfare and economic impacts) using a dynamic panel Sys-GMM estimator. The estimates of the T&D energy losses equation is first discussed, then electricity consumption per capita, and finally the estimates of the GDP per capita equation. The results in Tables 2.3-2.5 indicate that they fit the data well. The AR(1) and AR(2) test statistics indicate that there is first order serial correlation, but not at the second order, which suggests the inconsistency of OLS and appropriateness of a GMM estimator in this context (Arellano and Bond, 1991). In addition, the Hansen test of model specification and over-identifying restrictions indicates that all three models are correctly specified with appropriate instruments. The estimation strategy differs from earlier studies that use static models to analyse the impacts of ESR on performance (Zhang et al., 2008; Estache et al., 2009; Wren-Lewis, 2015).

2.5.1. Technical Impact – T&D Losses

The immediate impacts of ESR are the technical improvements on the sector. The estimates of the Sys-GMM estimation in Table 2.3 shows that, the coefficient of *cor* is negative and highly significant, suggesting that an increase in the corruption index (i.e., the country is

[19] The results of the robustness checks do not show major differences with respect to those finally presented in this chapter. These alternative models are presented and briefly discussed in Appendix I-2: Tables A2-A4.

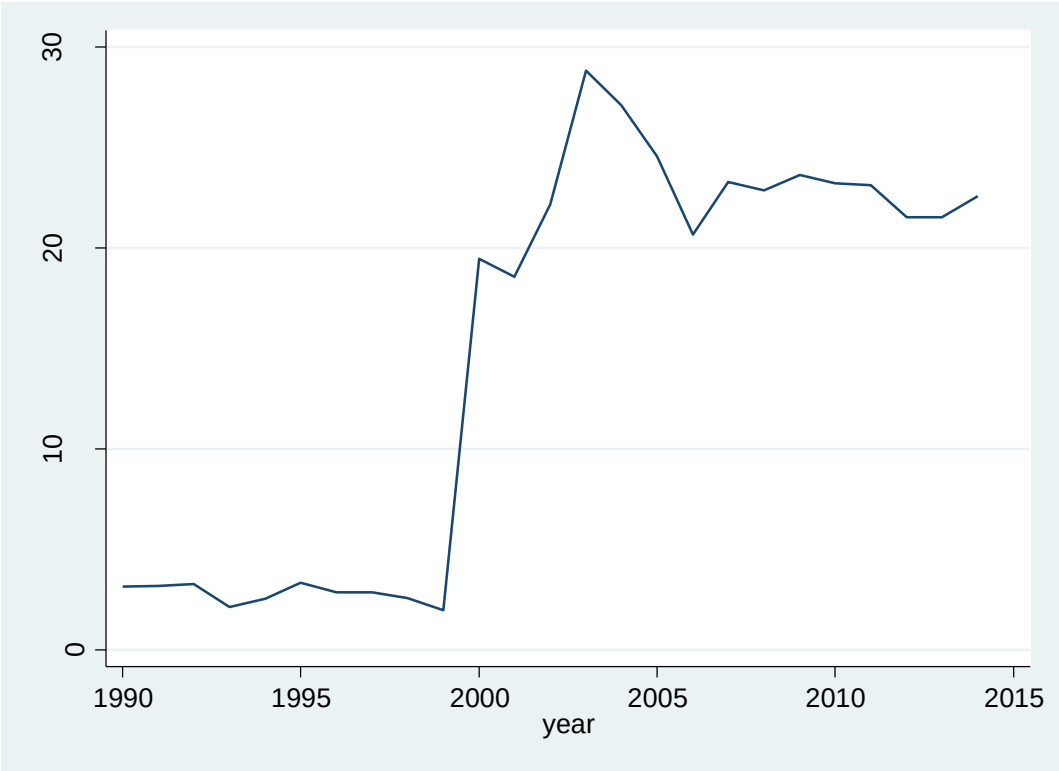
cleaner in terms of corruption) is associated with reduction in energy losses.[20] Thus, corruption can be considered here as a major source of inefficiency in SSA countries. Therefore, adopting measures to reduce corruption can have positive impact on technical efficiency. This result is similar to those obtained by other studies that have found a positive relationship between corruption and inefficiency in the sector (Dal Bó, 2006; Estache and Trujillo, 2009; Dal Bó and Rossi, 2007; and Wren-Lewis, 2015).

The coefficient of *ira* is significant and positive suggesting that, the creation of IRAs has led to a statistical increase in energy losses. A similar result was obtained by Nagayama (2010) who finds the establishments of IRA led to an increase in T&D losses in Latin American and some former Soviet Union countries. Similarly, Smith (2004) and Zhang et al. (2008) find reform policies such as the creations of IRAs are associated with deterioration in energy losses[21]. Similarly, as shown on Figure 2.1, there has been deterioration in energy losses post the creation of Ghana's electricity regulator (the Energy Commission).

[20] It should be noted that the dependent variable of this model, i.e., T&D losses, is expressed in the form of percentage and has not been log-transformed. This explains the large magnitude of the estimated coefficients, which must be interpreted as the effects, measured as changes in percentage points of the dependent variable, due to increases in the explanatory variables.

[21] As noted by Estache et al. (2009), there could be two explanations why there has been increase in losses: "(i) performance got worse or (ii) the measurement of actual performance improved with the creation of an IRA. In the second case, the apparent deterioration simply reflects better statistics; actual performance may even have improved".

Figure 2. 1: Ghana's T&D losses



Source: World Bank Development Indicators database

The coefficient of *priv* is not significant indicating that, private sector participation has no impact on the technical efficiency of the sectors during the period of the study. This result contrasts with Clark et al. (2005) who find the introduction of private participation in countries such as Namibia, Nigeria, Uganda and Mali is associated with efficiency improvements. This also contradicts earlier studies that find private participation in the electricity sector is associated with technical efficiency improvements (e.g., Andres et al., 2008; Nagayama, 2007; Balza et al., 2013).

Table 2. 3: Two-Step GMM Estimates of T&D Losses Equation

Technical Impact (*losses*)		
Variable	**Est.**	**t-stat.**
losses(t-1)	0.429***	4.42
cor	-16.431**	-2.19
ira	8.626**	2.24
priv	12.703	1.59
struc	1.081	0.67
iraXcor	9.749***	4.94

privXcor	9.342	1.18
iraXpriv	-2.105	-0.58
ln hols	-3.677***	-3.15
urban	0.015	0.21
time	0.228***	2.86
intercept	18.547***	3.80
No of obs.		231
No of countries		23
Instruments		22
AR(1) test (p value)		-2.26 (0.024)
AR(2) test (p value)		0.71 (0.475)
Hansen test (p value)		13.60 (0.192)

Significance code: *** p<0.01, ** p<0.05, * p<0.1

The failure of independent regulators and private sector participation in SSA countries to reduce the energy losses can in part be explained by the need of the reforms to initially direct their efforts to improve the conditions of the generation segment of the sector. This, however, in practice, often tends to come at the expense of delays in the regulatory reform of the transmission and distribution network utilities where most of the energy losses occur. Indeed, economic regulation of network utilities has proven to be a rather difficult task in developed as well as in developing countries.

Do electricity reforms reduce the influence of corruption on technical efficiency? This can be examined through the two interaction terms *iraXcor* and *privXcor*. The coefficient of *iraXcor* is positive and significant suggesting that creations of IRAs have a statistical impact on the relation between corruption and technical efficiency. The estimated coefficient suggests that IRAs has partially mitigated the influence of corruption on technical efficiency. The establishment of IRAs acts as a limiting factor of losses when corruption increases, but also limits loss reduction as countries become less corrupt. Smith (2004) argues that reform policies such as the creation of IRAs were not effective in reducing energy losses and especially electricity theft in developing countries such as in SSA. The study attributed this to weak quality of governance such as, ineffective accountability and political stability.

The coefficient of the *privXcor* interaction term is positive but not significant suggesting that, the SSA countries that have opened their electricity sectors to private participation have not been able to offset the negative influence of corruption on efficiency. Similarly, the coefficient of the interaction term *iraXpriv* is negative but not significant indicating that regularised privatised networks have no effect on technical efficiency. It appears that even though IRAs on their own increase energy losses privatization has no effect on technical efficiency. Nagayama (2010) obtained a similar finding in the former Soviet Union, Eastern European and Latin American countries.

Regarding the control variables, the negative and significant coefficient of *hols* suggests that an increase in household demand for electricity has led to reduced T&D losses, likely due to a positive size effect. The coefficients of *struc* and *urban* are not significant and suggest that unbundling and urbanisation have not influenced technical efficiency during the period of the study. The coefficient of the time trend is positive and significant thus indicating that there has been an increase in the electricity losses of the countries over the sample period. It should be noted that this and the subsequent results should be interpreted with some caution since the dummies used are nominal values and thus may not capture the intensity of reform policies among countries in the sample. Moreover, the measure of corruption used is at best the perception of corruption, which could be different from reality.

2.5.2. Welfare Impact – Per Capita Electricity Consumption

The main aim of electricity sector reforms in developing countries has been to improve the socio-economic welfare of the population. The parameter estimates of the performance equation (*access*) are presented in Table 2.4. The estimated coefficient of *cor* is positive and significant, suggesting that, an increase in corruption (i.e., a decline in *cor*) decreases access to electricity services. This result is consistent with the findings by other studies on how

corruption reduces the quality and quantity of publicly consumed services (e.g., Fredriksson et al., 2004; Estache et al., 2009).

The coefficient of the IRA dummy is positive and significant, indicating that for the period covered by the study, countries that have created IRAs have increased access to electricity. This result contrasts with those obtained by Estache et al. (2009) who associated the creation of IRAs with reduction in electricity access. The coefficient of *priv* is not significant indicating that the privatisation policies have no significant effect on electricity access. The estimate also contrasts with the findings of earlier studies such as Sihag et al. (2007) and Bhattacharyya (2006) who find that reform steps (e.g., privatisation) have led to a decline in access rates in the State of Orissa in India.

The coefficient of the interaction term *iraXcor* is positive and significant indicating that, creations of IRAs have amplified the influence of changes in corruption levels on electricity access, i.e., IRAs have been effective in enhancing electricity access when corruption has declined. The estimate of the interaction *privXcor*, is not significant suggesting that private sector participation has not been effective in addressing the negative influence of corruption. It may also suggest that corruption has not constrained the efforts of privatised utilities to increase access to electricity.

Regardless of the impacts of individual reform policies, the coefficient of *iraXpriv* suggests that together they exert a significant decreasing effect on access to electricity. In other words, although the creation of IRAs has led to increase in electricity access while privatisation has no effect, their interaction has led to reductions in electricity access. This may be attributed to the conflicting objectives of independent regulators and private utilities. Independent regulation may be keen to extend the often-subsidised service to mostly unelectrified poorer areas. However, private firms have shown little interest to extend the service to new low-

income and low-usage consumer groups.

The coefficients of *gdpper*, *urban* and *struc* are all not significant suggesting that income level, the size, and the structure of electricity markets have no impact on electricity access.[22] The electricity generation per capita variable (*genper*) is positive and highly significant indicating that further increases in electricity generation leads to increase in electricity access. The time trend is not significant indicating that there has been no improvement in the electricity access of the region over time.

The earlier results indicated that the implementation of electricity reforms in SSA countries can reduce the negative influence of corruption on the performance of the sector. Similarly, the implementation of reforms in developing countries was noted to have anticorruption potentials to reduce the effects of corruption on economic development (World Bank, 2000). Therefore, it is expected that the electricity reforms in SSA to enhance economic performance at two levels. First, by enhancing the performance of the sector by improving technical efficiency and extending the service to those without access. Second, as part of wider economic reforms, often underpinned by an anticorruption strategy, the reforms can reduce the effect of corruption on economic performance.

Table 2. 4: Two-Step GMM Estimates of Per Capita Energy Consumption Equation

Welfare Impact (ln *access*)		
Variable	**Est.**	**t-stat.**
ln access(t-1)	0.871***	23.46
cor	0.093*	1.74
ira	0.270***	2.86
priv	-0.051	-1.00
struc	0.032	1.09
iraXcor	0.157**	2.06

[22] The non-significant coefficient for *gdpper* could be related to an ambiguous relationship between per capita electricity consumption and income. It is expected that higher levels of per capita income imply higher per capita electricity consumption. However, it is also expected a negative relationship between these two variables for high levels of per capita GDP. This derives from the acquisition of more energy efficient appliances and the subsequent energy efficiency gains. We are grateful to an anonymous referee for pointing this out.

privXcor	-0.106	-1.60
iraXpriv	-0.209***	-2.97
ln genper	0.092**	2.17
ln gdpper	0.018	0.41
urban	0.001	0.92
time	0.001	1.13
intercept	-0.167	-0.62
No of obs.		515
No of countries		47
Instruments		37
AR(1) test (p value)		-4.04 (0.000)
AR(2) test (p value)		-1.55 (0.120)
Hansen test (p value)		31.74 (0.134)

Significance code: *** p<0.01, ** p<0.05, * p<0.1

2.5.3. Economic Impact – GDP Per Capita

In Table 2.5, where *gdpper* is a dependent variable in the performance equation, the coefficient of *cor* is positive and significant indicating that a decrease in corruption augments national income. This is consistent with other well-established findings on the relationship between these two variables (e.g., Barreto, 2000; Rose-Ackerman 1999; Shleifer and Vishny 1993). Thus, an increase in the corruption control index is associated with an increase in per capita GDP. The coefficient of *ira* is not significant; suggesting that creation of IRAs has not had impact on the level of income.

The coefficient of *priv* is positive and significant indicating that private sector investments have boosted economic performance of SSA reforming countries. A similar result was obtained by Chisari et al. (1999) who find privatisation of electricity generation and distribution assets led to positive economic performance in Argentina. Similarly, the estimate of *priv* confirms the argument by the IMF that ESR policies such as privatisation has the potential to free up energy subsidies and thereby boost economic performance over the long run (IMF, 2013).

Do the electricity reforms reduce the negative association between corruption and economic growth? The coefficient of *iraXcor* is not significant suggesting, that, for the period of this study, countries that established IRAs have not exerted beneficial effects on the negative association between corruption and per capita GDP nor has corruption affected the relation between regulation and economic performance. This is inconsistent with Jalilian et al. (2007) who stressed the importance of credible and independent regulation on economic growth. The coefficient of *privXcor* is positive and significant indicating that countries that open their electricity sectors to private investments have seen reinforced the influence of corruption on per capita GDP. Thus, countries with lower corruption levels have had further success in boosting income levels through private participation in the electricity sector.

The coefficient of *iraXpriv* is not significant suggesting that the interaction of the regulator and privatisation does not exert an influence on the economic performance. One of the two control variables in the model, *struc*, is positive and significant. This suggests that unbundling impacted positively on per capita GDP, after controlling for the effect of corruption. The time trend variable is significant which indicates that per capita GDP has increased over the period covered by the study.

Table 2. 5: Two-step GMM Estimates of Per Capita Income Equation

Economic Impact (ln *gdpper*)		
Variable	**Est.**	**t-stat.**
ln gdpper(t-1)	0.565***	7.20
cor	0.261***	3.38
ira	-0.050	-0.51
priv	0.140**	2.34
struc	0.237***	4.32
iraXcor	-0.185	-1.63
privXcor	0.238**	2.34
iraXpriv	0.006	0.10
urban	0.014***	3.75
time	0.001	0.73
intercept	2.563***	5.98
No of obs.		515

No of countries	47
Instruments	41
AR(1) test (p value)	-2.57 (0.010)
AR(2) test (p value)	-1.13 (0.259)
Hansen test (p value)	30.45 (0.443)

Significance code: *** p<0.01, ** p<0.05, * p<0.1

2.6. *Conclusion and Policy Implications*

Sub-Saharan African countries are noted to have some of the highest levels of corruption in the world. Various studies have studied how corruption has constrained the economic development of these countries through different transmission channels. However, one important transmission channel not yet investigated is the organisation and regulation of the electricity sectors. Research that has analysed this channel in other developing regions has found that corruption can reduce technical efficiency, restrict access to electricity services to urban areas, and reduce income levels.

In order to mitigate the influence of corruption in the electricity sector, reformers have called for the unbundling of state-owned utilities vertically (generation, transmission, distribution, and retailing) and horizontally (generation and retailing). The unbundled parts that are amenable to competition could be sold to the private sector and an independent regulatory agency would supervise and regulate the natural monopoly-prone networks of the sector.

After more than two decades of electricity reforms in SSA, researchers and policymakers can now study whether the reforms have reduced the influence of corruption on technical efficiency of the sector and whether the efficiency gains have resulted in higher electricity access and incomes. The chapter uses a purpose-built panel dataset and a dynamic panel estimator to investigate the effects of corruption on the performance of the sector. Using World Bank's control of corruption perception index, the chapter shows that corruption has an adverse and statistically significant effect on three performance indicators – i.e., technical

efficiency, access to electricity and economic performance. This finding adds to the body of evidence that stress the detrimental impacts of corruption on economic development and electricity sector performance.

The chapter finds that the creation of independent regulators and private sector participation, not only can enhance the performance of the sector but they can also have wider economic benefits. Specifically, the chapter find that independent regulation can increase social welfare although it can also reduce technical efficiency. In addition, the result show that private sector participation is associated with improved economic performance, while the result show that privatisation policies have no statistically significant impact on electricity access and technical efficiency.

Furthermore, the chapter also analyse how corruption interacts with different reform steps and how these interactions impact on the three indicators of performance. The creation of independent regulators has mitigated the association between corruption and technical efficiency, while it has amplified the relationship between corruption and electricity access, i.e., independent regulation has been effective to enhance electricity access in less corrupt countries. The chapter also find that creations of independent regulators have not mitigated the often-cited negative association between corruption and income level. Private sector participation has reinforced the influence of corruption on income. Thus, countries with lower corruption levels have had further success in boosting income levels through private participation in the electricity sector. However, private participation has no impact on the association between corruption and electricity access and technical efficiency.

The results suggest that implementation of well-designed micro level electricity reforms have the potential not only to boost the firms' economic performance directly, they would also indirectly reduce the negative effects of macro-level institutional deficiencies such as

corruption on micro and macro levels indicators of performance. For example, one of the policy implications from the results is the benefit of having an independent regulator that is transparent, fair, and accountable with the capacity for producing credible and predictable policies and with commitments to cost-reflective tariffs and protection of consumer interest. Establishing such an institutional body would not only help reduce uncertainties surrounding issues related to market access, tariffs, and revenues but also help improve the overall governance of the sector.

By improving sectoral governance, the regulator would reduce the need for risk mitigation measures such as World Bank guarantees, ring-fencing of revenues accruing to off-takers[23] and other measures required by investors when investing in SSA countries' power markets. Thus, by serving as a risk mitigator, the regulator would help attract the crucial investments needed to upgrade and build new transmission and distribution infrastructures and increase generation capacities thereby improving the overall performance of the sector.

Another finding of the study highlights the importance of privatizing SSA countries' state-owned utilities and incentivising private investors through well-delineated electricity policies that would be easily translated into investment opportunities. Therefore, at crux of the electricity reform should the desire to encourage investments needed to increase efficiency by reducing the large T&D losses which are the main feature of sectors in SSA electricity sectors. Also, privatised utilities when incentivised, would reduce nontechnical or commercial losses by improving metering, billing, and collection of tariffs, monitoring consumption regularly, particularly of the high-value consumers, and by enforcement of payment discipline among consumers.

[23] This would boost the creditworthiness of the off-taker.

Furthermore, the financial viability of the off-takers is important for attracting private investments since full wholesale or retail competition has not been achieved in the power sectors of the region.[24] This is because a financially fragile off-taker that does not recover enough revenue from consumers, would threaten the viability of whole system since it would be difficult for power generators to pay primary energy suppliers.

Although, the results emphasise the importance of independent regulation and private sector participation, this does not suggest that other aspects of the reform model such as unbundling and competition are irrelevant or unimportant. For example, unbundling would have the effect of levelling the playing field for private generating plants, while competition would allocate resources efficiently and lower tariffs for consumers. Therefore, all aspects of the reform model are important for improving the sectoral governance, strengthening the enabling environment, and reduce the risk perceived by prospective investors.

Overall, this chapter shows that implementation of electricity reforms in SSA countries have, to some extent, addressed the root cause of inefficiency and low access and thus have moved utilities towards better performance through cost recovery in pricing and improved metering, billing, and revenue collection. By improving the performance of the sector, some aspects of reforms have boosted economic performance, since improvements in technical efficiency can be translated into higher electricity access and national income.

[24] Despite reforms the SSA countries' state-owned utilities have remained the major buyers power.

Chapter 3: Political Economy of Reform and Regulation in the Electricity Sector of Sub-Saharan Africa

Abstract

As part of their electricity sector reforms, SSA countries have established independent regulatory agencies to signal legal and political commitment to end self-regulation and provision of service by the state. The reforms aimed to encourage private investments, improve efficiency, and extend the service to the millions who lacked the service. However, after nearly two and half decades of reforms, these expectations have not been met and the electricity sectors of these countries remain undeveloped. There are anecdotes that these outcomes are due to poor design, non-credible, unpredictable regulations, and political interference. This chapter investigates the performance of the reforms in the context of government political ideology. The chapter uses a dynamic panel estimator and data from 45 countries in Sub-Saharan Africa from 2000 to 2015 to investigate the ideological differences in the effect of independent sector regulation on access to electricity and installed capacity. The chapter find negative impact from independent regulatory agencies on installed capacity in countries with left-wing governments while in countries with right-wing governments they have positive effects on capacity. Also, chapter find negative impact on electricity access when regulators are established in countries with left-wing governments, while the chapter find no significant impact for the right-wing governments. The results have interesting policy implications for attracting private sector participation to increase generation capacity and access rates especially in countries with left-wing governments.

Keywords: independent regulatory agencies; electricity sector reforms; government ideology; dynamic GMM; Sub-Saharan Africa.

JEL classification: D73, Q48, L51, L94, O55, P16.

3.1. Introduction

Over the past three decades, SSA countries have aimed to reduce public ownership of electricity utilities through sectoral reforms. The reforms were partly due to critical budgetary conditions and part of macroeconomic stabilisation programs. Although no country in the region have implemented all aspects of comprehensive reforms,[25] the reforms have largely ended the era of self-regulation of the sector by the state. In its place, Independent Regulatory Agencies (IRAs) were created to regulate; set standards; define terms of interconnection among networks; issue, enforce or alter licences; and prevent abuse of dominant market position.[26]

These objectives may suggest IRAs were primarily established to promote economic regulation. However, as Thatcher (2002) have noted, independent regulators (as in other sectors) were also delegated powers over 'social' matters such as the promotion of universal access to services and protection of consumers from exploitations. In order to fulfil these mandates, IRAs were expected to reduce the risk to the private sector to increase generation capacity and extend the reach of electricity services (Jamasb et al., 2015) to the millions without access in the region (IEA, 2014). Despite these expected performance improvements from regulatory changes, SSA countries struggle to provide efficient and affordable electricity services to businesses and households (Eberhard et al., 2011) due to low generation capacity and underdeveloped distribution and transmission networks (World Bank, 2017; Ahlborg et al., 2015).

Some studies have linked the poor reform outcomes in developing countries to historical, financial, social, technical, political as well as economic factors (e.g., Dorman, 2014; Eberhard et al., 2011). Some researchers have shifted their attention to the institutional and

[25] With the exception of Nigeria, which have implemented all aspects of the reform model.
[26] These agencies were created as part of electricity sector reforms which were heavily advocated to developing countries by the International Monetary Fund (IMF) and the World Bank.

political context within which IRAs are embedded and expected to fulfil their regulatory functions (e.g., Imam et al., 2019; Pearce, 2006; Nepal and Jamasb, 2012a; Chang and Berdiev, 2011; Eberhard, 2007). These studies suggest that IRAs are susceptible to interferences particularly in countries with long history of weak institutions and unpredictable political intervention. For example, in countries with weak institutions, politicians may intervene in the functions of IRAs to favour state utilities at the expense of private utilities or require the IRAs to set artificially low tariffs which could erode the investments made by private utilities (World Bank, 1993).

As the reforms in the region have not led to full withdrawal of the state from the sector but rather to the emergence of hybrid electricity sectors with dominant state-owned utilities (Eberhard et al., 2016), there has been a lack of compatibility in these sectors between the governments political ideologies and the reforms which were often viewed as a neoliberal agenda (Gore et al., 2018). Therefore, in some SSA countries regulators have struggled to cater for the economic incentives of private utilities and social objectives of governments such as increasing access to affordable electricity services.

Despite the anecdotes that relate government ideology to regulatory outcomes in the region, there is a lack of empirical evidence that links political interference in the IRAs functions to electricity sector performance. Some studies have shown how energy regulators function under different institutional settings such as different government ideologies (e.g., Pitlik, 2007; Potrafke, 2010; Hibbs, 1977; Alesina, 1987). These studies suggest that right-wing governments tend to favour deregulation and privatisation, while left-wing governments favour interference in regulatory functions to advance their social objectives. Some studies have focused on the effect of government ideology on regulatory output (e.g., Fudge et al., 2008; Conway and Nicoletti, 2006; Serralles, 2002; Damsgaard, 2003). However, most of

these studies are either theoretical or on the experiences of developed countries where data are readily available.

To my knowledge, the chapter is among the few studies to empirically assess the impacts of electricity sector reforms in SSA countries (e.g., Imam et al., 2019) and is the first to empirically examine the effects of interactions between government ideologies of SSA countries and independent electricity sector regulators. Most studies of this strand of literature on developing countries tend to focus on specific aspects of institutional quality such as corruption (e.g., Imam et al., 2019; Estache et al., 2009; Wren-Lewis, 2015) or on specific countries without explicitly accounting for the role of political ideology apart from those earlier mentioned.

In order to fill this gap, the chapter uses a dataset on governments ideology first compiled by Beck et al. (2012) and later updated by Cruz et al. (2018) to investigate whether there are ideological differences in the effects of IRAs on electricity sector performance among SSA countries. Following Potrafke (2010), the sample is divided into three different government ideologies – left-wing, right-wing, and centrist governments in order to reflect the ideological orientation and different economic and social objectives of SSA countries. Whether a government transfers functions such as provision of electricity service to the private sector and make non-interference commitments depends not only on the degree of independence of the regulator, but also on the prevailing ideological orientation of the governments.

This chapter makes two contributions to the literature. First, the chapter contribute to the analysis of the institutional aspect of the reforms (e.g., Imam et al., 2019; Nepal and Jamasb, 2012a, 2012b; Dorman, 2014; Erdogdu, 2013) and the political economy literature on regulatory agencies (e.g., Kapiki and Eberhard, 2013; Pitlik, 2007; Potrafke, 2010; Scott and Seth, 2013). Second, the analysis of political ideology and electricity reforms provide insights

into why some SSA countries choose to reform while others do not. Why is it difficult to implement the Chilean and United Kingdom examples of rapid and full implementation of the textbook reform model? Why start reforms with the generation rather than the distribution segment? And, whether there are differences among reforming countries in terms of political commitments to allow regulatory agencies to function unhindered.

The remainder of this chapter is organised as follows. The chapter review the literature on energy reforms and ideology in Section 3.2. Section 3.3 presents the model, which tries to capture how government ideologies and independent regulators influence SSA countries' electricity sector performance. The section further presents the estimation strategy, data, and their sources. Section 3.4 discusses the obtained results. Section 3.5 concludes the chapter.

3.2. Literature Review

The role of energy in economic development has been well established in the literature even though there is no clear consensus on the direction of causality between them (Masih and Masih, 1997; Lorde et al., 2010; Burk et al., 2018).[27] Notwithstanding, researchers acknowledge that electricity is essential for the smooth operation of modern communications, industrial development, and enhancement of social amenities such as healthcare and education (e.g., Ahlborg et al., 2015). Due to its welfare enhancing effects, the business of electricity generation, transmission, distribution, and retailing have historically been the prerogative of the state and public sector and therefore closed to private investment (Conway and Nicoletti, 2006).

The historical dominance of the state was mainly due to the view that provision of electricity is among the central functions of governments especially in countries where the state

[27] A literature review by Narayan and Prasad (2008) showed that two-thirds of the studies published in the journals *Energy Policy* and *Energy Economics* find that energy production and consumption lead to economic growth in developed and developing countries.

occupies a large space in the economy (Victor and Heller, 2011). As a result, the electricity sector in most countries was dominated by vertically integrated state-owned utilities (Eberhard et al., 2005). Even in countries with significant number of private utilities such as the United States (Min, 2008), the government funded the development and construction of national electricity infrastructure such as the Tennessee Valley Authority and the Hoover Dam in 1920s and 1930s (Garwood and Tuthill, 1963; Hirsch, 1999). The Soviet Union at its founding in 1920s, created the State Commission for Electrification of Russia (GOELRO) to extend electricity services to the entire country (Min, 2008). Similarly, the governments of Germany, Netherlands, and Scandinavia made political commitments to electrify 90%t of households by 1930 (Nye, 1992). These interventionist policies show that no country successfully extended electricity to all its parts without the support of the state (Barnes and Floor, 1996).

However, beginning in the 1980s and in response to a combination of political, ideological, economic and technological factors the sector has undergone extensive restructurings to facilitate market solutions and private sector investments and participation (Jamasb et al., 2015). These restructurings, which were also referred to as the "Standard Textbook Reform Model", were part of a broader set of economic policy objectives that formed part of the 'Washington Consensus'. The reform model which were first implemented in Chile and the United Kingdom, provided evidence that its effective implementation would significantly enhance technical efficiency by reducing generation costs and price-cost gaps, and increase investment (Jamasb et al., 2015). Moreover, the efficiency gains are further expected to be translated into affordable access to improved services.

The electricity reforms aim to reduce the dominance of state-owned utilities in the sector (Dornan, 2014). Following the experiences of the pioneers and other OECD countries,

developing countries were encouraged by the IMF and the World Bank to unbundle the functions of electricity generation, transmission, distribution, and retailing. These countries would then sell the unbundled parts amenable to competition or regulation to the private sector and create independent regulatory agencies to supervise and regulate the monopoly-prone parts of the sector (Victor and Heller, 2007). Therefore, the main features of the Electricity Sector Reform (ESR) in developing countries were the introduction of market competition and private sector participation into the electricity markets.

In the 1990s, SSA countries began to implement ESR, even though no country in the region succeeded in implementing the entire suite of the reform model with the exception of Nigeria. This is because some aspects of the ESR model were viewed by politicians to pose differential risks; thus the reform parts considered as low-threats (e.g., entry of Independent Power Producers, IPPs) were mostly encouraged (Karekezi et al., 2004). Also, resistance to tariff increases by citizens who associate the reforms with neoliberal agenda, labour unions with socialist traditions, and Africans educated with Afro-socialist leaning views, galvanise to pressurise politicians to resist reforms even if the governments' view on ESR were positive (Batley, 2004; van de Walle, 1989; Gore et al., 2018).

Notwithstanding the politics surrounding the implementation of reforms in the region, as of 2014, 24 countries had enacted ESR laws, three-quarters had attracted private sector participation, two-thirds had corporatized their electricity utilities, a similar number had set-up regulatory bodies, and more than a third had IPPs in place (Eberhard et al., 2008). As a result, the dominance of governments in the sector has declined as they maintain their presence in the sector by creating IRAs to oversee and regulate the sector. The design and creations of IRAs which were influenced by the literature on central bank independence, credible commitments of governments and political uncertainties (e.g., Rogoff, 1985;

Thatcher, 2002), were motivated by the desire to insulate policies from future political interference, signal the credibility and commitments of reforming governments' to end self-regulation as well as replace political considerations by economic concerns (Estache et al., 2009; Pearce, 2006; Jamasb et al., 2004).

Therefore, IRAs are expected to protect private investors from the whims of the state, and consumers seeking protection from the incentives of dominant firm to influence prices through exerting market power or by tacit collusion with others (Jamasb et al., 2015). Also, the creation of IRAs does not entail complete abandonment of the role of government in the sector. Rather, it shifts the functions of government towards regulation and away from service provision, subsidising or financing of the sector. Therefore, the main outcome of implementations of an ESR is a switch from self-regulation or politically regulated provision of electricity to private sector provision of service and regulation by IRAs without political interference and conflict of interests (Estache et al., 2009).

The creation of the IRAs has been a major aspect of the reforms in SSA countries. During the period covered by this study, more than 50% of the countries in the region have established IRAs. These countries were also major beneficiaries of private sector investments (Eberhard et al., 2016). Table 3.1 shows the creation dates of the regulators in SSA. Performance of the regulators in the region has been mixed. For example, effective regulation has been credited with significant improvements in financial and operating performance of the privatised utilities (Eberhard et al., 2016). However, these contrast sharply with studies that argue that SSA countries continue to suffer socially and economically post the reforms, due to insufficient investment levels required to improve generation capacity and reliability of service, increase access rates, and reduce transmission and distribution losses (Aurial and Blanc, 2009; Eberhard et al., 2011; Ahlborg et al., 2015).

Table 3. 1 SSA Countries with IRAs

SSA IRAs and Year of Establishment	
Year	**Countries**
1994	South Africa
1997	Zambia
1998	Cameroon, Cote d'Ivoire, Senegal
1999	Niger, Madagascar, Uganda
2000	Ghana, Mali, Namibia, Togo
2001	The Gambia, Mauritania, Rwanda, Tanzania
2003	Cape Verde, Congo Republic, Zimbabwe
2004	Lesotho, Mozambique
2005	Central African Republic, Nigeria, São Tomé and Príncipe
2006	Kenya
2007	Angola, Malawi, Swaziland
2009	Benin
2010	Burkina Faso, Gabon
2011	Burundi, Sierra Leone, Sudan
2012	Seychelles
2014	Ethiopia

Source: Eberhard et al. (2016) and updated with data from Foster et al. (2017), https://openknowledge.worldbank.org/bitstream/handle/10986/28853/WPS8235.pdf?sequence=1&isAllowed=y; and Cape Verde, Seychelles, and São Tomé and Príncipe regulatory agencies' websites: Agência de Regulação Económica, http://www.are.cv/index.php; Seychelles Energy Commission, http://www.sec.sc/; and Autoridade Geral de Regulação, http://www.ager-stp.org/index.php/pt/.

Although, these poor reform outcomes have been attributed to a number of factors,[28] some have linked them to the broader national and institutional context within which IRAs are embedded (e.g., Minogue and Carino, 2006; Berg, 2000). This is because the quality of political institutions, credibility and reliability of the judiciary, institutional norms, administrative capacity and related factors were noted to have the potential to shape the functions of IRAs (Dubash and Rao, 2007). For example, in the SSA context, Eberhard (2007) argues that the failures of IRAs to achieve their mandates may be linked to unpredictable and inconsistent regulatory policies which are usually the fallouts of unstable and changing policy environments in which they operate.

[28] See World Bank (2017), Ahlborg et al. (2015), Eberhard et al. (2011), Sokona et al. (2012), and Khennas (2012) for details on these factors.

Similarly, Chang and Berdiev (2011), Pitlik (2008), Vowles (2008) and Bodea (2010) have noted that the degree of government fragmentation, institutional constraints, political strength and government authority can induce governments to reverse or change previous enacted policies such as commitment not to interfere in regulatory functions. For example, in Uganda, the electricity regulatory authority was routinely harassed by the government, summoned and questioned before the Parliament (although not accountable to the Parliament) for increasing electricity tariffs and investigated by the police (Kapika and Eberhard, 2013).

This shows that even though the regulators in the SSA countries are independent and have desire to improve efficiency and access rates, their regulatory powers can be undermined by the institutional environment in which they operate. Thus, institutions which consist of formal and informal rules and norms (North, 1990) may determine the incentives of governments not to interfere with regulatory functions. However, the main institutional factor identified by most studies, were political interferences in regulatory functions. Implementation of reforms in SSA was heavily influenced by domestic political dynamics and citizens expectations of state provision of electricity (Gore et al., 2018). Also, governments tend to fill positions in the regulatory agencies with political and financial allies in order to keep electricity prices low and to incentivise poor voters (Estache and Wren-Lewis, 2010). Karekezi and Kimani (2002) find examples of this in Kenya, Malawi, and Uganda.

Therefore, to understand the performance of the regulators in the region, the focus should not only be on technical aspects of regulation such as tariff setting methodologies and their implementations, but also on the larger contextual factors such as the political environment in which IRAs operate. This has led many studies to examine how political institutions influence the functions of IRAs in the sector (Imam et al., 2019; Chang and Berdiev, 2011; Cubbin and Stern, 2006; Erdogdu, 2013; Nepal and Jamasb, 2012b). These studies find

evidence that political factors impact regulatory decisions which in turn affect regulatory outcomes. Although, there are several reasons (e.g., redistribution and economic development) why politicians intrude into IRAs' functions, however, the most widely cited is the need to correct market failure and enhance citizens' welfare (Munger, 2008).

However, studies such as Pitlik (2007) suggest that although government interference may have detrimental effects, some regulation and public intervention is needed for a well-functioning economic system. Notwithstanding these conflicting arguments, a vast literature has emerged to show how governments based on ideological orientations of their political parties interfere in regulatory functions and influence outcomes (e.g., Benoit and Laver, 2006; Bjornskov and Potrafke, 2011; Duso, 2002). Similarly, other studies specific to the energy sector have shown how energy regulators function under different institutional settings such as under different government ideologies (e.g., Pitlik, 2007; Potrafke, 2010; Hibbs, 1977; Alesina, 1987). For example, analysis of political economy of energy reforms in developing countries have noted that consumer opposition to energy price increases often forces governments to reverse their earlier policy commitments.

Apart from consumer resistance to price increases, political opposition to reforms in developing countries was often backed by ideological arguments (Dorman, 2014). This is because political parties tend to promote economic policies in conformity with the ideology of their government (Hibbs, 1977; Chang and Berviev, 2011). Moreover, giving in to pressures from international multilateral organisations to transfer policy making powers to IRAs could depend on politicians who are more or less inclined towards the ideological orientations of their political parties. Therefore, government ideology may affect the functions of IRAs in SSA countries because it could determine government perceptions about these functions.

In this regard, the right-wing ideologies are mostly associated with policies aimed at protecting private property, deregulation, and privatisation which are all aimed at expanding the free market ideology. This has been supported by studies such as Pitlik (2007), Potrafke (2009) and Duso (2002), which show that liberalisation, deregulation, and privatisation policies are pursued by right-wing governments. In other words, right-wing governments promote economic freedom and prefer minimum government involvement in the economy, while left-wing governments are more likely to pursue social regulation to protect citizens from exploitation (Chang and Berdiev, 2011). Serrallés (2006) argues that the promotion of neoliberal economic ideologies mounted heavy pressure on the monopolistic European electricity sector to implement reforms.

The third consecutive general election victory for Thatcher government in 1987 contributed to the liberalisation and restructuring of state-owned electricity utilities in the United Kingdom (Damsgaard, 2003). As an opposite example, in Finland, where energy policy formulations and implementations have been dominated by the Centre Party and the Social Democrats, the production and import of electricity has been highly controlled and regulated by the government (Chang and Bendiev, 2011).

Therefore, in view of recent scepticisms towards neoliberalism and multilateral bodies, it is useful to analyse the political economy aspect of reforms and their outcomes in the SSA region. Some argue that, politics in SSA countries are not driven by government ideology, rather by other institutional factors such as corruption, political instability, and ethnic fractionalisation. For example, Mkandawire and Soludo (1999) and van de Walle (2002) argue that failures to implement reforms such as ESR, stalemates of reforms - where they have been initiated - or to attract private investments will not be explained by government orientations in SSA towards capitalism or socialism, self-reliance policies or globalisation.

Although, these arguments which are related to the weak governance literature and so far, have received great deal of attention, the main argument against the reforms in the region could be traced to the ideological beliefs of the governments about the role of the state in the economy. After gaining political independence, various governments in the region advocated for comprehensive ownership of means of production and concerted efforts were made towards a centralised management of the economy. For example, the Nkrumah government in Ghana pushed for the nationalisation of gold mines, while in Zambia the government took over the copper mines. Angola, Mozambique, Ethiopia, and Malawi adopted pure Marxism as form of government (Stambuli, 2002).

Similarly, with regards to sectoral reforms such as electricity, when SSA countries were confronted with the debt crisis of the 1980s, the World Bank and the IMF directed them to restructure their economies prior to the extension of financial support. The economic structuring mostly referred to as Structural Adjustment Programmes required them among other measures to reduce the control of government on the economy through privatisation of state assets and introduction of competition. As expected, there were widespread opposition towards such conditionalities which were seen as part of a neoliberal agenda (Nwagbara, 2004). Similarly, the current vertically-integrated nature of South Africa's electricity sector despite ESR, has been attributed to government focus on social imperatives; lack of regulatory and policy certainty; and conflicts in political ideology (Khan et al., 2016).

Furthermore, some case studies on ESR in SSA countries highlight that ideology is a very important factor in countries of the region. For example, Gore et al. (2018) find in Uganda, Tanzania, and Ghana, citizen expectations for the state to provide electricity were a significant factor that constrained ESR implementations. Despite these debates, and their tendency to shape the current political landscape as well as implementations of ESR, there is little evidence on how government ideology may have influenced the performance of

electricity sector reforms through regulatory decisions.

The above studies do not investigate the ideological differences in the impact of IRA on electricity sector performance. While IRAs are expected to increase efficiency, generation capacity, and expand access to service in SSA, the expected performance improvements of IRAs may be larger in some countries, especially in those with truly independent IRAs. While some of the reviewed studies treat IRAs and other institutional variables as exogenous (e.g., Estache et al., 2009), we treat these variables as endogenous, and use an Instrumental Variables (IV) estimator to investigate the impact of regulation and ideology on two indicators of electricity sector performance.

3.2.1. Hypotheses

The preceding subsection described how ideological orientations of governments could not only influence the creation of IRAs but also their subsequent credibility, independence, and performance. Thus, three hypotheses are formulated to test whether SSA countries have upheld the independence of IRAs or interfered in regulatory functions to advance their ideological objectives and what implications this has on the generating capacity of the sectors and expansion of access rates. In this regard, it is expected that right-wing governments to be more inclined towards creating credible, independent, and effective IRAs since they favour the protection of property rights, and legal equality which are the attributes of market-oriented economies. This is because implementation of electricity reforms entails reducing the reach of the government in the sector and introduction of market competition, thus it is more compatible with the ideological orientations of right-wing governments that tend to favour smaller size of governments.

Although, the right-wing ideology is widely associated with the freedom of choice and protection of property rights, the successful implementation of the reform model in Chile shows that ideology can also thrive under authoritarian regimes even though it is difficult for such regimes to make commitments due to time-inconsistency problem (McGuire and Olson, 1996). Therefore, SSA countries regarded as dictatorships are also capable of implementing reforms like their democratic counterparts. Thus, since building large-scale transmission and distribution infrastructures and extending them towards poor areas is costly (Ahlborg et al., 2015), it is expected that the benefits of having access to affordable and reliable electricity by low income households to be limited under right-wing governments since the ideology tends to be driven by economic motives. This observation brings us to the first hypothesis:

H1: *Governments associated with right-wing ideologies would create credible and effective IRAs to promote economic regulation thereby increasing the installed generation capacity but not the access rates to the service.*

Gilardi (2008) show that due to the pressure to make creditable commitments not to adopt interventionist policies post reforms, left-wing governments would create independent regulators and liberalise markets. Thus, the creation of IRAs by left-wing governments can be seen as a commitment device since they are more likely to pursue policies aimed at protecting consumers. In contrast to right-wing governments which aim to pursue economic regulation, left-wing governments tend to pursue social regulation. However, extending services to those without access will also depend on increasing the capacity of utilities. Therefore, left-wing governments will also have incentives to support investments to increase capacity. Although left-wing governments have incentives to promote social regulation aimed at protecting citizens from the consequences of liberalisation (Ennser-Jedenastik, 2016; Hawkins and

Hutler, 1993), they may also promote economic regulation especially when these interventions could fulfil their social objectives. This leads to the second hypothesis:

H2: *Left-wing governments may interfere with IRA functions to increase both generation capacity and access rates.*

Although, some governments in SSA are observed to be inclined either towards the left or the right in the dataset compiled by Cruz et al. (2016), there are other SSA governments that do not easily fit into neither of the two wings. In other words, such government policy objectives consist of ideologies of the two competing wings, focused on strengthening private enterprise in a social-liberal context and hence party platform does not focus exclusively either on economic or alternatively on social issues. These group of countries are categorised as having centrist governments based on the definitions in Cruz et al. (2016)[29] on government ideology. Thus, the final hypothesis is:

H3: *There will be uncertainty on IRA's credibility, when there are competing wings in the government or governments that do not have clear economic or social objectives thus performance may improve or deteriorate.*

3.3. Methodology

3.3.1. Econometric model

In order to analyse the effects of political ideologies and IRAs on performance, an econometric model is specified and estimated. The study postulates that electricity sector performance (*esp*) depends on a dummy that indicates whether an independent regulatory agency exists in country *i* at year *t*, and a vector of control variables (*x*). In order to capture the ideological differences on the performance of IRAs (*ira*), two ideology dummy variables included– left-wing (*left*) and right-wing (*right*) that interact with *ira* as regressors. The

[29] For definitions and categorisations of government ideology see Cruz et al. (2016).

comparison group consists of the countries in the sample, are categorised as centrist governments. The coefficients of the interaction terms show the effect of ideological differences on electricity sector performance. The performance model estimated is given in (3):

$$esp_{it} = \alpha_i + \beta_1 ira_{it} + \beta_2(left_{it} \cdot ira_{it}) + \beta_3(right_{it} \cdot ira_{it}) + \sum_{q=1}^{Q} \beta_{4q} X_{it} + \varepsilon_{it} \qquad (3)$$

where *esp* is the performance indicator reflecting either of the two performance indicators: total installed capacity and access to electricity (i.e., access rates, *access*). βs are parameters to be estimated, α_i are country-specific effects and control for time-invariant unobservables and $\varepsilon_{it} \sim N(0, \sigma^2)$, is the stochastic error term. The vector *x* of control variables includes GDP per capita, total electricity generation, the size of electricity markets, corruption, and a time trend (*time*) to take into account technical change. Also, included as controls are two dummy variables indicating whether a country has privatised its utilities and has opened its electricity sector for private investments and has unbundled its electricity sector.[30]

3.3.2. Estimation strategy

Using the pooled Ordinary Least Squares (OLS) estimator to estimate the parameters of Equation 1 yields inconsistent and unreliable results for two reasons. First, due to the presence of endogenous variables such as corruption (*corr*) and GDP per capita (*gdpper*), and second, the likely correlation between country-specific factors (captured by α_i) such as history, colonisation, and culture, and other regressors. This issue could be addressed by using a Fixed Effects (FE) estimator to ameliorate the bias arising from unobserved heterogeneity and endogeneity of regressors. An issue is that most indices and dummy variables in the model have little variation over time, which may lead to large standard errors of the coefficient estimates if an FE estimator is utilised. The Random Effects (RE) estimator

[30]This consists of four types of private sector investments in power sector utilities of SSA namely management and lease contracts, brownfield, greenfield projects, and divestures.

is not appropriate either because, as noted, the regressors are likely to be correlated with unobserved country-specific factors.

Apart from the sources of endogeneity, reform performance equations tend to be represented as dynamic (e.g., Imam et al., 2019; Jamasb et al., 2015; Wintoki et al., 2012). In other words, performance depends not only on the current values of the regressors, but also on their past values. The OLS, the FE, and the RE estimators cannot produce consistent coefficient estimates in the presence of endogenous regressors and dynamics. Instead a dynamic panel General Method of Moments (GMM) estimator proposed and developed in a series of studies (e.g., Arellano and Bond, 1991; Arellano and Bover, 1995; Blundell and Bond, 1998) is used. These studies, particularly Arellano and Bond (1991), proposed two estimators, the one-step and the two-step GMM. The study uses the two-step GMM estimator because it provides more efficient estimators over the one-step GMM estimator (Gyimah-Brempong and de Camacho, 2006).

The use of a dynamic panel two-step GMM estimator improves on both the OLS and FE estimators by allowing for the inclusion of country-specific effects (α_i) to account for time-invariant unobserved heterogeneity, and the current performance to be influenced by previous realisation of performance. Similarly, unlike Two-Stage Least Squares (2SLS) which relies on difficult and sometimes unreliable instruments, the Difference GMM (Diff-GMM) estimator relies on internal instruments contained within the panel. In other words, past values of the regressor and performance can be used as instruments, and this eliminates the need for external instruments.

However, Diff-GMM estimator like the FE not only eliminates α_i, but also removes all time-invariant variables through differencing the model during estimation. As noted by Roodman (2008), Diff-GMM performs poorly in the presence of persistent processes because the

lagged levels may convey little information on future changes. As a result, the estimator tends to produce inconsistent estimates since the differencing produces weak instruments.

Arellano and Bover (1995) and Blundell and Bond (1998) improved on the shortcomings of the Diff-GMM estimator and developed its variant, the System GMM (Sys-GMM) estimator which allows for the inclusion of time-invariant regressors, which would have otherwise disappeared in the Diff-GMM estimation. Thus, the estimator solves the problems of endogeneity of regressors and dynamics by treating the model as a system of equations in first differences and in levels. It does so by instrumenting the endogenous regressors by lags of their levels, while instrumenting those in the level equation with lags of their first differences. The study uses these advantages of dynamic panel System GMM estimator to obtain consistent estimates. This entails transforming Equation 1 into a dynamic panel specification where the lagged values of the two performance indicators (installed capacity and access rates) are included as additional regressors in (4):

$$esp_{it} = \varphi esp_{it-1} + \alpha_i + \beta_1 ira_{it} + \beta_2 (left_{it} \cdot ira_{it}) + \beta_3 (right_{it} \cdot ira_{it}) + \sum_{q=1}^{Q} \beta_{4q} X_{it} + \varepsilon_{it} \quad (4)$$

where esp_{it-1} denotes the lagged value of performance, whilst φ is the parameter associated with that variable. All other variables and coefficients are defined as before. Using the dynamic System GMM estimator to obtain consistent and unbiased results depends on two specification tests. The first is a Hansen test for overidentification restrictions which is a joint test of model specification and appropriateness of the instrument vector. Failure to reject the null hypothesis of the test indicates that instruments used in estimation are valid and the model is well specified. The second is the Arellano and Bond (1991) test for serial correlation of the disturbances up to the second order. The appropriate check of the test for serial correlation (AR) relates only to the absence of second-order serial correlation, AR(2), since the first differencing induces first-order serial correlation, AR(1), in the transformed errors.

3.3.3. Data

Dependent variables

The dependent variables in the model are installed capacity (*cap*) and access rates (*access*). Generation capacity is measured as total installed capacity and access rate by percentage of total population with access to electricity. There are several ways to measure both, none of which is ideal. The analysis focus on these two indicators of performance, because for SSA governments to increase access rates and meet supressed demand, install capacity must grow by more than 10% annually (Eberhard et al., 2011). Therefore, it is expected that reforms would increase the generation capacity and access to affordable electricity. Data on annual installed capacity (*cap*)[31] and access (*access*) were sourced from the United States Energy Information Administration (EIA), and the World Bank Development Indicators Database. Additionally, electricity consumption per capita (*comper*) has been used as dependent

[31] Total installed capacity may increase but operating capacity may remain low if there are no corresponding investments in both transmission and distribution segments required to evacuate and transport the electricity to end users.

variable in one model presented in the Appendix. Data on total electricity consumption averaged by total population was obtained from the United Nations Energy Statistics Database, while the data on total population was obtained from the World Development Indicator Database.

Independent variables

Information on government ideology is sourced from Beck et al. (2012) database of political institutions and updated by Cruz et al. (2016) which classifies governments as either left-wing, right-wing, centrist, or lacking an ideology. The variable ranges between 0 and 3, where the value 1 represents right-wing governments, the value 2 represents centrist governments, 3 represents left-wing governments, and countries without ideology were coded as 0. Three dummy variables are constructed in order to reflect the three respective government ideologies of SSA governments.[32]

In addition to the government ideology index, the Freedom House measure of freedom ratings[33] is used which consists of a combined score of a country's political rights and civil liberties to investigate the robustness of the estimates. In other words, freedom rating is the total sum of two ratings –political rights and civil liberties ratings. The rating is dichotomised at 5.5, based on Freedom House's judgement that countries with scores of 2.5 and below are free, countries with scores from 3.0 to 5.0 are partly free and countries with scores of 5.5 and above are not free. These scores are used to construct three dummy variables[34] to reflect the level political rights and civil liberties in SSA countries. The Freedom rating is used since it

[32] In the category of centrist governments, countries which lack ideology and countries without information on government ideology in the database are also included.

[33] For more understanding and how both the government ideology and Freedom House indexes were measured and vary overtime please see:
https://www.researchgate.net/publication/324418292_Database_of_Political_Institutions_2017 &
https://freedomhouse.org/report/freedom-world-2016/methodology

[34] The intuition for this is that free societies are mostly associated with *laissez faire policies that aimed to reduce the role of the state in economic affairs and thereby avoid interfering with individual freedom.* Moreover, Erdogdu (2013) argues that ESRs have been more extensive in countries with more investment freedom.

is generally accepted that human freedom or liberty is intimately related or interwoven with property rights which are mostly associated with right-wing governments. Conversely, countries with left-wing governments tend to implement policies that put property rights at risk thereby discourage private investments, innovation and beneficial risk taking. Therefore, strong legal protections for property rights are a necessary condition for attracting the private sector investments to increase both generation capacity and access rates.

The data on the independent regulatory agencies (*ira*) is drawn from Eberhard et al. (2016) and updated with additional data from Foster et al. (2017), Cape Verde, Seychelles, and São Tomé and Príncipe electricity regulatory agencies' websites as indicated in Table 3.1. Following Jamasb et al. (2004), a dummy variable is created that takes value 1 to indicate the existence of an IRA and 0 otherwise. The existence of an IRA has been associated with improved electricity sector performance (Cubbin and Stern, 2006), while political institutions can influence and improve the performance of IRAs (see Nepal and Jamasb, 2015).

Control variables

We include corruption (*corr*) in the model since the implementation of ESR also entails reducing the corruption levels (World Bank, 2000) which are noted to have a significant impact on generating capacity of utilities and access (Estache et al., 2009). We use the control of corruption index obtained from Kaufmann et al. (2010) which is included in the World Bank Governance Indicator Database. The corruption index, which measures corruption in both public and private sectors, ranges from -2.5 (highly corrupt) to 2.5 (highly clean).

Summary statistics of the data used in the estimations are presented in Table 3.2. The summary statistics indicate that total installed capacity, access, and other variables vary greatly across the SSA countries in the sample. For example, there is a wide variation in the data on installed capacity with *cap* ranging from a low of 0.01 GW for Liberia in 2005 to a high of 46.12 GW for South Africa in the same year. The sample therefore includes countries with high level of installed generation capacity as well as countries with very low levels of installed capacity.

In order to represent the demand side, we use two control variables. First, previous studies have shown that investments are needed to increase both the generating capacities of utilities and increases in access rates are largely dependent on level of economic development (Zomers, 2001; Ahborg et al., 2015). Thus, we include a measure of countries' GDP per capita (*gdpper*). Second, we include the percentage of population that lives in urban areas (*urban*) as a proxy for size of electricity markets. The data on both variables were obtained from World Bank Development Indicators Database.

Table 3. 2: Summary Statistics of the Data

Variables	Labels	Unit	Obs.	Mean	Std. Dev.	Min.	Max.
Dependent Variables							
Access Rates	*access*	%	720	33.17	23.86	0.01	99.4
Installed Capacity, Total	*cap*	GW	720	1.76	6.49	0.01	47.44
Elect. Consumption, Total	*comper*	GWh	716	356.22	659.32	1.61	4,187
Independent Variables							
Regulator	*ira*	Dummy	720	0.57	0.50	0	1
Centrist governments	*centre*	Dummy	565	0.02	0.14	0	1
Left-wing governments	*left*	Dummy	696	0.25	0.43	0	1
Right-wing governments	*right*	Dummy	696	0.10	0.30	0	1
Partly free governments	*pfree*	Dummy	720	0.45	0.50	0	1
Not free governments	*nfree*	Dummy	720	0.33	0.47	0	1
Free governments	*free*	Dummy	720	0.16	0.37	0	1

Control Variables							
Privatisation	*priv*	Dummy	720	0.57	0.50	0	1
Structure	*struc*	Dummy	720	0.10	0.30	0	1
Elect. Generation, Total	*gen*	GWh	720	8,439	36,139	21.68	263,479
Corruption	*corr*	Index	675	-0.64	0.59	-1.77	1.22
Ethnic fractionalisation	*ethnic*	Index	720	0.67	0.22	0	0.93
Conflict	*conflict*	Index	720	0.57	1.45	0	7
Ruggedness	*rugged*	Index	720	1.26	1.59	0.15	6.66
Latitude	*lat*	Degrees	720	0.01	14.21	-29.58	20.26
GDP, Per Capita	*gdpper*	2010 US$/Inhab.	701	2,006	2,953	193.87	20,334
Population Density	*popden*	Inhab./km^2	716	86.23	118.35	2.31	621.97
Urbanisation	*urban*	%	716	38.63	16.60	8.25	86.12
Population Growth	*poprate*	%	716	2.56	0.84	0.13	5.54

Note: *access, cap, comper, gen, gdpper* and *popden* were log-transformed prior to estimation.

On the supply side, we include total electricity generation (*gen*) and two ESR variables, privatisation (*priv*) and structure of the electricity market (*struc*). Data on *priv* was obtained from the World Bank Infrastructure Database. Data on *gen* is sourced from United Nations Energy Statistics Database, while data *struc* of the electricity market is from Foster et al. (2017). The database is composed of annual observations for a sample of 45 SSA countries for the period 2002-2015.[35] For robustness checks of the results, we add two each of institutional variables (ethnic fractionalization and conflict), topographical variables (ruggedness and latitude) and demographic variables (population density and population growth) to both installed capacity and access rates equations. For data sources, descriptions of these variables as well as the results of the robustness tests see section 3.3.

3.4. Results

This section presents the coefficient estimates of the installed capacity and access equations using the dynamic panel Sys-GMM estimator. The first subsection discusses the estimates of

[35] SSA countries in the sample are: Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Comoros, Dem. Rep. Congo, Rep. Congo, Cote d'Ivoire, Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Gabon, The Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia, and Zimbabwe. Countries contained in the sample were dictated by data availability especially data on ideology.

the installed capacity equation while the second subsection discusses the estimates of access equation. We then report two robustness tests of the results. The regression statistics presented at bottoms of all results tables indicate that the models fit the data well. Arellano and Bond (1991) tests for serial correlation, AR(1) and AR(2), indicate that there is first order serial correlation, but not at the second order, which shows the inconsistency of OLS and the appropriateness of using a GMM estimator in this analysis (Arellano and Bond, 1991). In addition, Hansen's test of model specification and overidentifying restrictions indicates that the models are correctly specified with appropriate instruments. Failure to reject the null hypothesis of the test indicates that the instruments used in estimation are valid and the model is well specified.

3.4.1. Total installed generation capacity

The results of the two-step Sys-GMM estimates of the installed capacity are presented in Table 3.3. The coefficient of *ira* is positive and significant indicating that, all things being equal, the establishment of an IRA is positively correlated with improvements in generation capacity. This result is in line with results obtained by several other studies (e.g., Cubbin and Stern, 2006; Nakano and Managi, 2008). This is also consistent with Eberhard et al. (2016) observation that countries that established IRAs (e.g., Cameroon, Côte d'Ivoire, Ghana, Kenya, Nigeria and Uganda) were able to increase installed capacity by attracting new IPPs compared to countries without IRAs. However, this result contrasts with results obtained by some studies (e.g., Nagayama 2010; Zhang et al., 2008) on the effects of IRAs on installed capacity.

The results support the view that IRAs help mitigate or insulate IPPs from investment risks especially when investing in weak institutional environments. For example, the Energy Regulatory Commission of Kenya helped reduce the power purchase agreement charges radically between the first set of IPPs negotiated and the second (Eberhard and Gratwink, 2011).

The coefficients of both *left* and *right* are not significant suggesting that, the effect of the two government ideologies on installed capacity are not different from that of centrist governments in SSA countries. The coefficient of *priv* is positive and significant indicating that privatisations of hitherto state-owned utilities and other forms of private participations have increased generation capacity. This result is consistent with Eberhard et al. (2016) observation that private utilities post reforms, account for more than 25% of SSA countries' total installed generation capacity. Moreover, other empirical studies have found private sector investments in electricity sector are positively correlated with performance improvements (e.g., Cullmann and von Hirschhausen, 2008; Zhang et al., 2008; Megginson and Netter, 2001; Nagayama, 2010). However, the result contrast with other studies that find IPPs and other forms of private sector participation have no impact on generation capacity (e.g., Bonifaz and Santín, 2000).

The coefficient of *struc* is negative and significant, indicating that structure of electricity sectors, especially the unbundling of the hitherto state-owned utilities, has negatively affected generating capacity of utilities. This may indicate that in the five countries that unbundled their electricity markets in SSA, it could be that system operators are grappling with the complexities of coordinating generation and transmission post reforms. The result contrast with those of Nepal and Jamasb (2012b) who find that reform measures such as unbundling did not result in efficiency improvements in the sector and Nagayama (2010) who finds that key reform measures (i.e., unbundling, IPPs investments, and establishment of IRAs) has led

to improved efficiency.

Table 3. 3: Two-step GMM Estimates of Total Installed Capacity Equation

Total Installed Capacity (*cap*)		
Variable	**Est.**	**t-stat.**
cap (t-1)	0.910***	42.68
ira	0.261***	5.41
left	-0.022	-0.32
right	-0.152	-1.11
priv	0.141***	2.88
struc	-0.597***	-3.37
iraXleft	-0.195**	-2.61
iraXright	0.343**	2.27
corr	0.200	1.24
ln *gdpper*	0.111*	1.68
urban	-0.002	-0.72
intercept	-0.764*	-1.76
No of obs.		590
No of countries		45
Instruments		42
AR(1) test (p value)		-2.46(0.014)
AR(2) test (p value)		0.88(0.381)
Hansen test (p value)		26.80(0.634)

Significance code: *** p<0.01, ** p<0.05, * p<0.1

The coefficients of *corr* and *urban* are both insignificant indicating that, corruption and size of electricity markets has no statistical impact on generation capacity. These estimates especially on corruption, contrasts with those obtained by Imam et al. (2019), Wren-Lewis (2013) and Estache et al. (2009) for technical efficiency. However, this result may be explained by the choice of installed capacity as dependent variable. This is likely because electricity generating utilities, especially IPPs, seeking to mitigate investment risks while operating in weak institutional environments such as in SSA countries, often sale their electricity output to off-takers or require sovereign and World Bank guarantees thereby effectively insulating them from corruption. The coefficient of *gdpper* is positive and

significant indicating that income has positive impact on the installed capacity of the sectors.

Are there government ideological differences in efficiency impact of IRAs? The answer is provided by the coefficient estimates of the two interaction terms. The coefficient of *iraXleft* is negative and significant, suggesting that installed capacity impact of IRAs in countries with left-wing governments is lower than impacts of IRAs in countries with centrist governments. This result is in line with the results obtained by earlier studies that showed the adverse effects of left-wing governments on regulation (e.g., Pitlik, 2007; Bjørnskov, 2005) and thus regulatory outputs.

The coefficient of *iraXright* is positive and significant, implying that the generation capacity effect of IRAs is larger in countries with right-wing governments than those with centrist governments. This result is in line with Potrafke (2010), Bortolotti et al. (2003), and Bortolotti and Pinotti (2008) who noted that right-wing governments favour the independence of IRAs to promote their economic objectives.

The coefficients of the interaction terms also reinforce the arguments of the World Bank (1993) and Megginson and Netter (2001) on how interventionist policies such as government financed provision of electricity and sheltering of utilities from competition tends to be less efficient compared to services provided by private utilities in competitive electricity markets. This is because countries that have institutionalised the protection of property rights and rule of law [36] (Acemoglu and Verdier, 1998) are mostly the countries that attract private investments in the form IPPs and thus increase their generating capacity in SSA (Eberhard et al., 2006). In contrast, In SSA countries with history of interventionist policies, aversion to neoliberal reforms or with leaders who can effectively use the institutions of the state to reward loyalists or punish foes, less ESR have been implemented (van de Walle, 2001) and direct government regulation of the sector exist.

[36] Mostly associated with right-wing governments.

The interactions coefficient estimates suggest that we reject Hypothesis 2 and thus conclude that left-wing ideologies by interfering with IRAs' functions have led to lower generation capacity in SSA countries during the period covered by the study. And we fail to reject Hypothesis 1, which suggests that right-wing governments promote IRAs' independence and thus have increased generation capacity. These two coefficient estimates indicate that there are significant differences in terms of ideology in generation capacity effects of regulators. We therefore reject the proposition that there are no ideological differences in the generation capacity of IRAs.

3.4.2. Access to electricity (access rates)

There are conflicting arguments in the literature on the definition of access rates.[37] For example, Min (2008) use share of population in unlit areas based on analyses of satellite night time images, while Ahlborg et al. (2015) and Estache et al. (2009) have used electricity consumption per capita and kilograms of oil used per capita as indicators of electricity access rates. Notwithstanding the conflicting choice of indicators by these researchers, we have used the percentage of total population of a country with access to electricity services as dependent variable in the access equation. However, we have also presented the estimation results for electricity consumption per capita in the Appendix.[38]

The coefficient of *ira* in Table 3.4 is positive and significant suggesting that, that SSA countries that have established IRAs have increased access rates. This result confirms the result obtained by Imam et al. (2019) on the positive impacts of SSA countries' IRAs on access improvements and World bank (2017) report that show how Rwanda's electricity regulator (RURA) by overcoming regulatory risks that inhibit electrification efforts, was able to reduce connection costs and increased access rates from 6% in 2008 to 16% in 2012[39].

[37] See Ahlborg et al. (2015), Min (2008), and Doll and Pachauri (2010) on choice of access indicators.
[38] The results in the Appendix II-1 Table: B1 confirm the estimates of the access equation presented in Table 3.4.
[39] This was achieved in conjunction with Electricity Sector Wide Approach (eSWAp) policy of the Rwanda.

Similar findings were established by studies on other developing countries. For example, studies, such as Cubbin and Stern (2006) and Zhang et al. (2008), find regulatory governance as a result of power sector reforms have not only expand generation capacity expansion, utilization of generation capacity and reserve margin, but also enhanced service penetration.

Table 3. 4: Two-step GMM Estimates of Access Rates Equation

Access Rates (*access*)		
Variable	**Est.**	**t-stat.**
access (t-1)	0.727***	107.11
ira	0.094***	3.22
left	0.004	0.23
right	-0.121**	-2.58
priv	-0.039***	-3.25
struc	-0.020	-0.76
iraXleft	-0.115***	-4.27
iraXright	0.083	1.62
corr	0.042	1.23
ln gdpper	0.090***	7.00
ln gen	0.034***	4.80
urban	0.004***	4.30
intercept	-0.067	-0.97
No of obs.		590
No of countries		45
Instruments		43
AR(1) test (p value)		-2.51(0.012)
AR(2) test (p value)		-0.10(0.920)
Hansen test (p value)		33.02(0.322)

Significance code: *** p<0.01, ** p<0.05, * p<0.1

The coefficient of *right* is negative and significant suggesting that access to electricity is lower in countries with right-wing governments than countries with centrist governments. This result is consistent with the arguments that right-wing governments provide less for basic needs (Moon and Dixon, 1985) and prefer minimum government involvement in the economy (Chang and Berdiev, 2011). The coefficient of left is insignificant indicating that

government.

access rates effects of left-wing governments are not different from that of countries with centrist governments. The coefficient of *priv* is negative and significant suggesting that privatisation of utilities and other forms of private sector participation have led to reductions in access rates. This result consistent with other findings that show how privatisation policies have led to access rates reductions (e.g., Bhattacharyya, 2006; Sihag et al., 2007) and led to concentration of services to profitable areas in SSA countries (Victor, 2005). Similarly, in Nigeria were the distribution segment has fully been privatised, the distribution companies have no incentives to expand services due to non-implementation of cost reflective pricing.

The coefficient of *struc* is not significant suggesting that unbundling of electricity sectors of SSA countries have no effect on access. The coefficients of *gdpper*, *urban* and *genper* are all positive and significant indicating that average income, the size of electricity markets and electricity production have all boosted access to electricity services in SSA countries during the period covered by the study. This is because post reforms implementations, increased income level, expansion of transmission and distribution networks, and electricity generation especially by private utilities have helped expand the electricity supply capacity and thus enhanced access to electricity (Jamasb et al., 2016).The coefficient of the interaction term *iraXleft* is negative and significant.

This indicates that, the access rate impact of IRA in SSA countries with left-wing governments is lower than those of countries with centrist governments. This result suggests that ideologically motivated interventions especially by left-wing governments in regulatory functions have constrained the efforts of IRAs to incentivise utilities to increase access rates. In fact, a significant number of SSA countries' electricity utilities well-documented failures to extend services to the millions without access has been blamed on inappropriate regulation and government intrusiveness, rather than effectiveness of ESR (Kipaki and Eberhard, 2013; Eberhard et al., 2016).

The coefficient of *iraXright* is not significant, suggesting that the access rates effect of IRAs in SSA countries with right-wing governments is not different from that of SSA countries with centrist governments. These two estimates entail the rejection of Hypothesis 1 and Hypothesis 2 which postulated that interference in the regulatory functions by left-wing governments, increases access rates while by right-wing governments have access reducing effects.

Moreover, these estimates contrast with the ideas presented by some theoretical works (e.g., Gilardi, 2005; Hawkins and Hunter, 1993) that left-wing governments place more weight on social issues (e.g., access to electricity by the poor) and thus interfere in the IRAs functions to promote social regulation. Similar arguments were put forward on the effects of right-wing governments. For example, right-wings governments associated with promotion of competition and preventing dominant firms from abusing market power (Ennser-Jedenastik, 2016), are also expected to increase social welfare indirectly through these policies. The results did not live up to the expectations of these theories and indicate that there are significant differences in access rates effects of political ideologies.

3.4.3. Robustness test

It is possible that the obtained results on installed generation capacity and access rates impacts of IRAs and ideologies are affected by omitted variable bias or choice of the ideology variable. Hence, in this subsection we test the robustness of the estimates of the two performance indicators. We begin by adding six addition regressors (two each of demographic, institutional, and topographical variables), two at a time, to both to the installed capacity and access rates equations to see if this would significantly change the coefficient estimates of the two interaction terms. We then estimate the two equations by using an alternative of measure of ideology (Freedom Index) to see if the results are driven by the

choice of the institutional index used.

3.4.3.1. Additional regressors.

Min (2008) argue that physical geography of a country and countries at higher absolute latitude influences investments in electricity infrastructure needed to extend services especially to those in rural areas. Excluding these two variables from the performance equations could, potentially, lead to biased coefficient estimates of the effects of IRAs and government ideologies on installed capacity and access rates. Therefore, the variables ruggedness (*rugged*) and latitude (*lat*) are used as additional regressors in the two performance equations. *Rugged* is measured in hundreds of meters of elevation difference for grid points 30 arc-seconds (926 meters on the equator or any meridian),[40] while *lat* is expressed in decimal degrees, for the geographical centroid of a country. Data on both variables were obtained from Nunn and Puga (2012).

Other studies have argued that ethnic fractionalization and, civil wars and conflicts are among the major challenges facing efforts to increase infrastructure investments and increase access to electricity services (Min, 2008; Ahlborg et al., 2015). Therefore, an include index of conflict which is the total summed magnitudes of both societal and interstate conflicts (*conflict*)[41], and a time-invariant ethnic fractionalization (*ethnic*) index are added to the two performance equations. These two variables are obtained from Alesina et al. (2003) and Marshall et al. (2017) respectively.

[40] However, the measure used in this chapter is an index which gives more weight to densely populated areas.
[41] This index varies overtime reflecting the onset and end of conflicts and thus it also captures the cessation of conflict in SSA countries as democracy takes root in the region.

Table 3. 5: Two-step GMM Estimates of Total Installed Capacity Equation

Installed generation capacity (*cap*)						
	rugged + latitude		***ethnic + conflict***		***popden + poprate***	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Variable	**Est.**	**t-stat.**	**Est.**	**t-stat.**	**Est.**	**t-stat.**
cap(t-1)	0.923***	45.09	0.911***	43.27	0.644***	9.68
ira	0.258***	6.92	0.415***	5.62	0.846**	2.08
left	0.026	0.45	0.056	0.86	0.070	0.25
right	-0.180	-1.49	0.010	0.09	0.075	0.16
priv	0.096***	2.91	0.134***	3.07	0.235	1.66
struc	-0.378**	-2.26	-0.984***	-4.10	-2.765***	-3.26
iraXleft	-0.239***	-3.59	-0.371***	-4.39	-0.625*	-1.79
iraXright	0.192*	1.87	0.415*	1.90	1.581**	2.46
corr	0.275	1.67	0.210*	1.95	0.335**	2.39
ln *gdpper*	0.125**	2.24	-0.059	-0.62	-0.414*	-1.75
urban	-0.003	-1.11	0.002	0.48	0.017	1.61
rugged	-0.028	-1.36	-0.009	-0.52	0.005	0.04
lat	0.003	1.36	-0.003	-1.11	-0.030*	-1.92
ethnic			0.329	1.31	2.607*	1.91
conflict			-0.030**	-2.06	0.013	0.58
ln *popden*					0.091	1.10
poprate					-0.153	-1.41
intercept	-0.710*	-1.86	0.020	0.03	0.043	0.03
No of obs.		590		590		590
No of countries		45		45		45
Instruments		44		40		39
AR(1) test (p value)		-2.45(0.014)		-2.48(0.013)		-2.37(0.018)
AR(2) test (p value)		0.90(0.366)		0.76(0.444)		-2.29(0.771)
Hansen test (p value)		25.90(0.680)		23.32(0.501)		18.02(0.648)

Significance code: *** p<0.01, ** p<0.05, * p<0.1

Finally, several studies find population density (*popden*) and growth rate of population (*poprate*) to have effects on electricity sector performance (Min, 2008; Imam et al., 2019; Eberhard et al., 2016). Therefore, annual population density, which is in people per square kilometres of land area and growth rate of total population is added. Data on *popden* is from

the World Bank Development Indicators Database while data on *poprate* is from the United Nations, Department of Economic and Social Affairs, Population Division (2018).

Table 3. 6: Two-step GMM Estimates of Access Rates Equation

Access rates (*access*)						
	rugged + latitude		***ethnic + conflict***		***popden + poprate***	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Variable	**Est.**	**t-stat.**	**Est.**	**t-stat.**	**Est.**	**t-stat.**
access(t-1)	0.734***	83.60	0.705***	88.13	0.735***	56.22
ira	0.116***	3.01	0.060**	2.18	0.047**	2.63
left	-0.003	-0.13	0.020	0.84	0.069	1.61
right	-0.119*	-1.75	-0.093*	-1.84	-0.075*	-1.85
priv	-0.040***	-2.93	-0.004	-0.24	-0.020	-0.92
struc	0.032	1.31	0.026	1.00	0.181**	2.52
iraXleft	-0.109***	-3.11	-0.080**	-2.67	-0.150***	-3.17
iraXright	0.054	0.92	0.035	0.77	-0.065	-1.42
corr	0.114***	2.76	0.034	0.95	0.061	1.39
ln *gdpper*	0.072***	3.56	0.037	1.28	0.035	1.24
ln *gen*	0.024***	2.85	0.053***	5.78	0.061***	6.08
urban	0.0052***	4.09	0.008***	6.10	0.007***	3.84
rugged	0.029**	2.58	0.012	0.64	-0.008	-0.72
lat	0.002**	2.11	0.005***	5.50	0.007***	6.96
ethnic			-0.525***	-4.14	-0.480***	-3.12
conflict			-0.013*	-1.84	-0.096***	-4.87
ln *popden*					0.010	0.81
poprate					-0.042**	-2.60
intercept	0.063	0.57	0.425*	1.94	0.446*	1.84
No of obs.		590		590		590
No of countries		45		45		45
Instruments		39		41		43
AR(1) test (p value)		-2.56(0.010)		-2.53(0.011)		-2.49(0.013)
AR(2) test (p value)		-0.03(0.975)		-0.02(0.983)		-0.20(0.839)
Hansen test (p value)		21.36(0.618)		21.37(0.617)		22.40(0.555)

Significance code: *** p<0.01, ** p<0.05, * p<0.1

The results of the robustness test are presented in Tables 3.5-3.6. Columns 1, 3, and 5 in both tables present the coefficient estimates of *iraXleft, iraXright* and the rest of the variables when the six variables divided into 3 different sets are included as additional regressors in the capacity and access equations. Coefficients of the dummy interactions remain significant and with the same signs regardless of the additional regressors included in the two equations. The coefficient of *ira* also remain significant and with the same sign. The estimates suggest that the ideology dummy variables are not acting as proxies for some omitted regressors which should have been included in the global performance equations.

3.4.3.2. Alternative measure of ideology (Freedom House Index).

The results of the installed capacity and access estimations are based on the ideology index compiled by Beck et al. (2012) and updated by Cruz et al. (2018). It is possible that the earlier obtained results are driven by this choice of index. To investigation this possibility, an alternative institutional index – the Freedom House Freedom rating- is used to investigate the ideological differences in the performance impact of IRAs.

The results of the estimations of installed capacity equations and access rates using the Freedom House index as the alternative measure of ideology is presented in Table 3.7. The coefficient estimates of IRA is significant and positive in both estimations, thus confirming the earlier obtained results. The coefficient of the dummy interaction terms in both columns 1 and 2 remain significant and with the same signs regardless of the freedom rating used as a proxy for the ideology index in both two equations. In other words, these estimates suggest that freedom differences in the performance effects of *ira* found in this section are similar to the ideological differences in the performance impact of *ira* found above and thus the earlier results are not driven by the ideological index used.

Table 3. 7: Two-step GMM Estimates of Access and Installed Capacity Equations.

	Capacity Utilization		Access Rates	
	(1)		(2)	
Variables	Est.	t-stat.	Est.	t-stat.
ln cap (t-1)	1.020***	147.61		
ln access (t-1)			0.748***	161.63
ira	0.069***	4.03	0.147**	2.49
nfree	0.014	0.40	0.219***	3.96
free	-0.138***	-9.10	-0.134	-1.65
priv	-0.032**	-2.39	-0.061**	-2.61
struc	-0.070***	-4.77	0.172***	6.80
iraXnfree	-0.053**	-2.09	-0.167***	-3.08
iraXfree	0.061***	4.85	0.029	0.35
corr	-0.024	-1.00	0.268***	5.18
ln gdpper	0.027	1.53	0.061*	1.74
urban	0.001	0.34	0.005***	0.46
ln gen			0.004	3.70
intercept	-0.133	-1.38	0.288	1.47
No of obs.		613		613
No of countries		45		45
Instruments		44		43
AR(1) test (p value)		-2.33(0.020)		-2.97 0.003
AR(2) test (p value)		0.95(0.344)		-0.37(0.708)
Hansen test (p value)		31.70(0.482)		29.80(0.476)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

3.5. Conclusions and policy implications

The common and important feature of electricity sector reforms in Sub Saharan Africa over the past two and half decades, has been the creation of independent regulatory agencies. These new institutional bodies were mandated to regulate and oversee the electricity market and look after consumer interest. IRAs were expected to depoliticise electricity price-setting and encourage private sector investment through transparent and predictable decisions. By fulfilling these regulatory tasks, IRAs were to increase the generating capacity and access to electricity services. Despite the anticipated performance improvements, there is some evidence that the region's electricity sectors are still bedevilled by low generation capacity, poor network infrastructure, and large group without access to services.

Numerous studies have linked the poor outcomes to factors such as historical, economic, financial, and corruption related factors. However, political economy factors have received

less attention in the literature. For example, some studies have noted that, political ideology of governments may promote or constrain regulatory functions. The chaper focuses on the influence of political ideology on IRAs and their regulatory effectiveness. Panel data and a dynamic panel data estimator is used to investigate ideological differences in the effects of IRAs on total installed capacity and access rates.

The result show that IRAs have positive and significant effects on both generation capacity and access rates. Similarly, the result show that there are significant ideological differences in the effects of IRAs on installed capacity and access rates. The largest negative effects of the interactions between IRAs and ideology on installed capacity and access rates is found in SSA countries with left-wing governments. The results are robust after controlling for additional variables and different measure of ideology that have impacts on electricity sector performance.

What policy implications can be derived from the results? All the SSA countries that have implemented ESR aimed to achieve certain level of economic development through increasing the productivity of their electricity sectors and access to electricity. The results imply intrusion into regulatory functions especially by left-wing governments would lead reductions in investments need to increase generation capacity and expand access rates since regulatory decisions would be viewed by investors as politicised. This means that countries with left-wing governments cannot expect large inflows of private sector investments or a stable and efficient electricity sector, all necessary conditions for achieving a higher and sustained level of economic development. The implication of the results is that countries with left-wing governments can increase the growth rate of income by taking steps to reduce interferences in IRAs functions, because this will not only increase generation capacity, but would also lead to higher access rates.

The performance impacts of IRAs' are not uniform in all SSA countries. Therefore, while it may be necessary to strengthen the independence of IRAs in all SSA countries to signal credibility and attract the needed private sector investments to increase generation, expand transmission and distribution infrastructure and access rates, may not be equally pressing in all countries of the region. As noted, the need to reduce interference in regulatory functions to attract private sector participation into electricity generation and boost access rates is more pressing in countries with left-wing governments and countries with centrist governments than it is in countries with right wing governments.

Therefore, SSA governments with different ideologies should place differential emphasis on policies to strengthen the independence of IRAs as a means of improving efficiency and access rates. While strengthening the independence of IRAs in left-wing governments may be critical for increasing capacity and access rates, it may not be as critical for right-wing or centrist governments, especially in increasing capacity. Then giving more independence to IRAs or not interfering in their functions in SSA countries by the same proportion will not only improve increase capacity and access, it will also help narrow the gap among the countries with different ideologies, since SSA countries with low installed capacity and access rates will benefit the most by boosting the independence of IRAs.

These results should be interpreted with caution as the proxies for IRA and government ideologies do not reflect the degree, extent, or intensity of regulation nor the dynamics or incentives of governments. There is a need for further studies to investigate regime (e.g., democracy and autocracy) difference in the effects of reforms to enhance the understanding of the link between performance and politics as well as other institutional factors that may constrain regulatory functions and private investments.

Chapter 4: Electricity Access and Human Development in Sub-Saharan Africa

Abstract

Despite implementations of electricity sector reforms and other policies to increase electricity access, there is limited empirical evidence on the impacts of electricity access post these policies implementations on human development. This chapter examines the impact of access to electricity on Human Development Index (HDI) and its three components (i.e., health, education, and income), using panel data on 49 SSA countries from 2002 to 2013. Through dynamic panel estimation, the chapter shows that increased access to electricity has positively boosted human development. Similar results are found on the impact of electricity access on the three HDI components. The results suggest that eradicating energy poverty mostly associated with the Sub-Saharan Africa is one of the most important channels of boosting human development.

Keywords: human development, electricity access, Sub-Saharan African, dynamic panel data.
JEL classification: C26, I15, I25, O15, Q48.

4.1. Introduction

In most SSA, increasing access to electricity has been identified as the most important channel of enhancing economic development, even more important than access to finance or fighting corruption (IEA, 2016). This has been evidenced by the implementation of various initiatives aimed at increasing electrification rates and development of electricity markets (United Nations Economic Commission for Africa; UNECA, 2007; Osterkorn et al., 2010). Starting from 1990s, many SSA countries have implemented ESR to improve the financial and technical efficiency of their utilities (Imam et al., 2019) and to free up government resources to expand access to electricity (Jamasb et al., 2016). Additionally, SSA countries have recently signed up to multilateral initiatives such as the African Union's Agenda 2063 and Sustainable Development Goals (SDGs) of United Nations to expand access rates.

Assessments of the effects of these interventions especially on ESR show modest access rates improvements post policy interventions (Imam et al., 2019; ESMAP, 2011). A joint report by the UNECA, Africa Union Commission (AUC), African Development Bank (AFDB) and United Nations Development Programme (UNDP) regional bureau for Africa on Africa's progress on the SDG 7 noted that, access to electricity has increased from 39.7% in 2008 to 45.9% in 2014 (UN, 2018). Some studies have shown that increased electrification rates have had positive impacts on economic performance (Samli, 2011; Stern, 2011; Bacon and Kojima, 2016). However, recently the focus has shifted to effects of electrification on human development (Todaro and Smith, 2012). Since the aim of any public policy is to enhance citizens' welfare, higher access rates are expected to bring about positive socio-economic benefits.

There is evidence of human development improvements where electricity has been provided, due to benefits from lightning, education, health, leisure and security (e.g., Davis, 1997; Karekezi and Majoro, 2002; Kirubi et al., 2009; Spalding-Fecher, 2005). Kirubi et al. (2009)

show that electricity provision in Kenya has benefited rural communities socially and economically by enhancing the productivity of workers. Similarly, Karekezi and Majoro (2002) in a study on South Africa and Zambia, find that electrification increased the number of businesses that offered various services in South Africa, while in Zambia electrification reduced the consumption of charcoal, wood and kerosene by 15, 35 and 47 % respectively.

Notwithstanding, the benefits of improved access, Eberhard et al. (2011) noted that electricity provision in many SSA countries has been skewed towards higher income households and urban areas since utilities do not have incentives to extend the service to poor and unprofitable areas (Transnational Institute, 2002; Victor, 2005). This has been identified as one of the reasons why SSA countries continue to lag behind the rest of the world regarding provision of universal access to electricity (Ahborg et al., 2015). This has led some researchers to question the social benefits of policy interventions such as ESR (Auriol and Blanc, 2009), especially as 80% of the region's population still relies on traditional use of biomass to meet their energy needs (Hancock, 2015). Table 4.1 presents the number of people relying on traditional biomass for their energy needs in SSA countries compared to other developing regions of the world.

Table 4. 1: Population relying on traditional biomass (million), by region, 2015.

Region	Population relying on biomass
Developing Countries	2500
Africa	784
North Africa	1
Sub-Saharan Africa	783
Developing Asia	1648
Latin America	57
Middle East	10

Source: IEA, Energy Access Outlook (2017).

Without electricity access, it is difficult to fulfil basic human needs. Despite extensive policy discussions and efforts to increase access rates in the region by multilateral institutions,

governments and private bodies, the impact of electricity access on the human development of SSA countries has been under-explored. Therefore, the chapter examines the matter in SSA countries. Analysing the relationship between access rates and human development is important for two reasons.

First, a significant number of studies on electrification and human development is focused on other developing countries in Asia or Latin America or use mixed panels of developed and/or developing countries. As a result, it is difficult for SSA policy makers to learn lessons from them because circumstances differ in terms of institutions, economic structure and electricity markets. Second, studies that assess the impact of policy interventions such as ESR on welfare indirectly through its effects on electricity access are mostly qualitative case studies combined with social cost-benefit analysis at micro level or single country cross-sectional household survey data (Lee et al., 2016). Thus, it is difficult to find empirical studies on SSA countries using a panel data approach.

This chapter addresses these deficits and contributes to the literature in four ways. First, to the best of my knowledge this is the first study to analyse the impacts of improved electricity access on human development by solely focusing on SSA countries, thereby decreasing the cultural and institutional heterogeneity that characterized most cross-county studies. Second, the chapter extends the literature on ESR which has been largely focused on the direct impacts of reforms on social welfare in SSA countries (e.g., Imam et al., 2019; Eberhard et al., 2011; Eberhard et al., 2016) by focusing on realised used of electricity.

Third, the chapter contributes to a better understanding of how infrastructure would help enhance the overall development and productivity of countries as well as quality of citizens' life (e.g., Mohanty et al., 2016; Ahborg et al., 2015; Sen et al., 2018). Fourth, the chapter also emphasises the importance of electricity access in achieving Goal 7 of the United Nations'

Sustainable Development Goals (SDGs) that aims to ensure access to affordable, reliable, sustainable and modern energy for all (UN, 2018).

This chapter is organised into five sections. Section 4.2 reviews the relevant literature and discusses the channels through which electricity access impacts human development. Section 4.3 presents the hypotheses to be tested. Section 4.4 introduces the empirical methodology and the data used in the study. Section 4.5 shows and discusses the results. Section 4.6 concludes the chapter.

4.2. Literature Review

Electricity access accelerates human development through the integration of technologies into issues such as irrigation, creation of employment, enhancement of work, and improving the provision of both health care and education (Karekezi et al., 2012). As a result, most SSA countries have recognised its importance in this regard (Parshall et al., 2009) and have made increasing access to electricity their national priorities (APP, 2015; Deshmukh et al., 2013; Scott and Seth, 2013). Prioritising electricity access as a national objective in developing countries has its roots in the historical views about states' role in the provision of social services (Scott and Seth, 2013) and benefits from economies of scale in generation, transmission and distribution of electricity (Banerjee, 2006; Pachauri and Brew-Hammond, 2012).

Recently, most SSA countries have signed up to various initiatives such as the Agenda 2063[1] of the African Union (African Union Commission, 2015), the Sustainable Development Goals of the United Nations (UN, 2018) and the Sustainable Energy for All[2] (SE4All) - a multi-stakeholder partnership between civil society, governments and the private sector

[1] One of its goals is to connect SSA countries through world class infrastructure.

[2] SE4All was set up to ensure universal access to modern energy services; double the global rate of improvement in energy efficiency; and double the share of renewable energy in the global energy mix.

Yumkella and Holliday, 2012). These agendas were all aimed at providing opportunities for the countries of the region to tackle the challenges of sustainable development (including poverty eradication) and climate change mitigation (Care and WWF, 2016) though access to modern, affordable and reliable energy.

Furthermore, SSA countries like other developing countries have implemented extensive restructurings of their electricity sectors to facilitate market solutions and private sector investments and participation (Jamasb et al., 2015) aimed at complementing public resources to increase electricity access (Nepal and Jamasb, 2012; Estache et al., 2009). There have been some modest improvements in increasing electricity access post these policy interventions. For example, access to electricity has relatively improved significantly, with even a small acceleration since 2010 (IEA, 2015). For example, access increased from 35 to 43% between 2012 and 2014 (IEA, 2017; Ahborg et al., 2015).

Similarly, the corporatization of South Africa's state-owned utility ESKOM, has increased the percentage of people with access from a third of the population to about 70% of the population (Eberhard et al., 2005). It was also reported that electricity access has more than doubled in Ghana and Mali. and where electricity access has been provided in SSA countries, the social and economic conditions of people have improved in terms of education, health, lightning and security (Karekezi and Majoro, 2002; Kirubi et al., 2009; and Spalding-Fecher, 2005). This shows that increasing or extending access to affordable and reliable electricity services to households, health centres, schools and businesses in the region, brings substantial long-term socio-economic benefits (Ahborg et al., 2015).

However, apart from some of these modest achievements attributed to policies implementation, SSA have not succeeded in radically expanding electricity access. This is because, in absolute terms, the number of people without access has increased as infrastructure development has lagged behind the population growth (Lucas et al., 2016). As

a result, 588 million people are still without basic electricity access (IEA, 2017).

Table 4. 2: Access Rates in SSA countries in 2016.

	National	**Urban**	**Rural**	**Population without access** (million)
SSA Countries (Average)	42%	71%	22%	600
Angola	35%	69%	6%	17
Benin	32%	56%	11%	8
Botswana	55%	69%	32%	1
Burkina Faso	20%	58%	2%	15
Burundi	10%	35%	7%	10
Cameroon	63%	94%	21%	9
Cape Verde	97%	100%	89%	<1
Central African Republic	3%	5%	1%	5
Chad	9%	32%	1%	13
Comoros	71%	89%	62%	<1
Congo	43%	56%	16%	3
Cote d'Ivoire	63%	88%	32%	9
Democratic Republic of the Congo	15%	35%	0%	68
Djibouti	42%	54%	1%	<1
Equatorial Guinea	68%	93%	48%	<1
Eritrea	33%	86%	17%	4
Ethiopia	40%	85%	29%	61
Gabon	90%	97%	38%	<1
Gambia	48%	66%	13%	1
Ghana	84%	95%	71%	5
Guinea	20%	46%	1%	10
Guinea-Bissau	13%	23%	1%	2
Kenya	65%	78%	60%	17
Lesotho	34%	63%	24%	1
Liberia	12%	16%	3%	4
Madagascar	23%	52%	7%	19
Malawi	11%	49%	3%	16
Mali	41%	83%	6%	11
Mauritania	31%	47%	2%	3
Mauritius	100%	100%	100%	-
Mozambique	29%	57%	15%	21
Namibia	56%	78%	34%	1
Niger	11%	54%	0%	18
Nigeria	61%	86%	34%	74
Rwanda	30%	72%	12%	8

Sao Tome and Principe	59%	70%	40%	<1
Senegal	64%	90%	44%	6
Seychelles	99%	99%	99%	<1
Sierra Leone	9%	12%	6%	6
Somalia	16%	35%	4%	9
South Sudan	1%	4%	0%	13
Sudan	46%	71%	31%	22
Swaziland	84%	90%	71%	<1
Tanzania	33%	65%	17%	37
Togo	35%	74%	5%	5
Uganda	19%	23%	19%	33
Zambia	34%	67%	7%	11
Zimbabwe	34%	81%	11%	11

Source: IEA, Energy Access Outlook (2017).

Furthermore, there are significant differences among countries of the region in terms of electrification rates. For instance, in 2016, 86% of South Africa's population had electricity access, while in South Sudan only 1% had access. Disparity also exist between urban and rural areas in terms of access. Of the 80% of the population that live in rural areas, only 22% had electricity access, compared to 71% with access in urban areas (IEA, 2017). In Nigeria, it is estimated that only 34% of the rural and semi-urban population have electricity access while nationally, 61% of the population – over 74 million people have no access (IEA, 2017). Table 4.2 shows the disparities among and within SSA countries in terms of access rates. Much of the increased electrification in the region occurred in urban areas with rural areas being the most underserved (World Bank and IEA, 2015; Eberhard et al., 2016).

This shows that policies aimed at diversifying electricity sources could have a significant impact on electricity access especially in sparsely populated rural areas far from the central grid and thus boost economic development. As a result, some countries of the region have created rural electrification agencies to extend services where the grid has not reached or unlikely to reach in the near future (Bhattacharyya, 2012). Such intervention has been a crucial part of socio-economic development (Cook, 2011) as it has been noted to have

boosted both agricultural and non-agricultural incomes (Kirubi et al., 2009) and in some countries, it has increased female labour participation rate (Dinkelman, 2011).

While off-grid solutions have received favour and support of international organisations and donor agencies, there has been a relatively limited penetration in the region as in other parts of the world because limited efforts have been made to apply them for productive use or income generation (Bhattacharyya, 2012). Similarly, very limited effort has gone into hybrid off-grid solutions to provide a reliable and affordable solution, because of system complexity, added cost and over-emphasis on lighting-only solutions (Bhattacharyya, 2012). Pachauri and Brew-Hammond (2012) argue that, like other developing countries, the historical overdependence on the central grid and neglecting of mini-grid and stand-alone systems have hammered rapid electrification efforts in SSA countries. These show over reliance on central grid systems as the main factor constraining the efforts to extend electricity to the millions without access in the region.

Compared to other developing regions of the world, the number of people without electricity access in SSA countries is the highest (IEA, 2017). The average number of people in 2016 without access in Latin America, the Middle East and Asia are 3, 7 and 11%, respectively, while in SSA about 57% of the population lack access to electricity (IEA, 2017). See Table 4.3 for disparities in terms of access rates among different develop regions of the world. Similarly, when the SSA countries electrification rates are compared with other developing countries, the disparities are glaring. For example, post policy interventions such as ESR implementations, electrification rates in Argentina, Peru and El Salvador respectively increased to 95, 72 and 76% from the respective pre-reform rates of 91, 38 and 62% (Jamasb et al., 2016). The number of households without electricity supply in Chile decreased to 14% in 2002 from 62% in 1982 after implementing reforms (Pollitt, 2004).

Table 4. 3: Access Rates in Developing Countries in 2016.

Regions	National	Urban	Rural	Population without access (million)
Developing Countries	82%	94%	70%	1060
Africa	52%	77%	32%	588
North Africa	100%	100%	99%	<1
Sub-Saharan Africa	43%	71%	23%	588
Developing Asia[3]	89%	97%	81%	439
Latin America	97%	98%	86%	17
Middle East	93%	98%	79%	17

Source: IEA, Energy Access Outlook (2017).

The poor access rates in SSA countries relative to other developing countries has been blamed partly on the large cost of building of large-scale transmission and distribution networks to extend services to difficult terrain, dispersed and/or low populated areas; inability of poor households to pay connecting charges and the weak financial status of utilities (Ahborg et al., 2015; World Bank. 2017). It has been estimated that $40.8 billion (6.35% of Africa's GDP) of investments is required annually to achieve universal energy access in the region by 2030 and approximately two-thirds of this is needed for capital investment ($27.9 billion a year); the remainder is for operations and maintenance (Eberhard et al., 2016). Of the capital expenditure, about $14.4 billion is required for new power generation each year, and the remainder for refurbishments of existing networks (Eberhard et al., 2011). As a result, SSA countries lack the required infrastructure to ensure access to affordable, reliable, sustainable and modern energy for all its citizens despite various policy implementations (IEA, 2014).

As a result, SSA countries suffer economically and socially due to low electricity access, insufficient generation capacity, unreliable service and poor transmission and distribution networks (Eberhard et al., 2011; World Bank and IEA, 2015). Lack of access to electricity is correlated with low levels of human development (approximated by the Human Development Index, HDI, and the percentage of population that have access to electricity). SSA countries

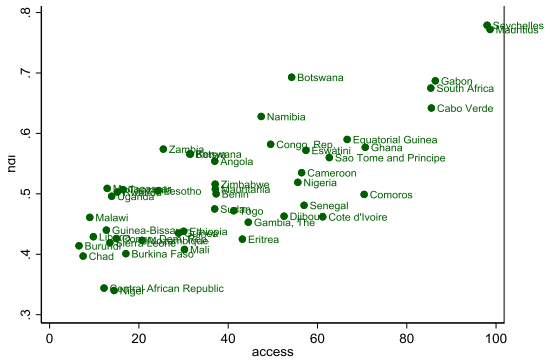
[3] Excluding China and India.

with low human development also tend to have low access to electricity as shown in Figure 4.1. This relationship between human development and access above suggest that, individuals who lack access to reliable and affordable electricity access tend to lack opportunies for income generation and have low levels of education and life expectancy. Conversely, where access to electricity has been expanded, the health of the people, housing conditions and educational outcomes improve, thus contributing to overcoming poverty (Kerekezi et al., 2012).

This has led some studies to investigate the impact of infrastructure deficit on economic development of SSA countries. Calderón (2008) assessed the impact of infrastructure stocks on growth in SSA countries between the early 1990s and the early 2000s and find that if SSA countries were to catch up with the regional leader, Mauritius, in terms of infrastructure stock and quality, their per capita economic growth rates would have to increase by an average of 2.2% per year. The study also finds that reaching the infrastructure stock of South Korea would increase their rates of economic growth by 2.6% annually.

This is consistent with Escribano et al. (2008) finding that low access and unreliability of service have adversely affected the economic growth of SSA countries especially through firms' productivity. This finding which was based on a World Bank's survey data show that, ahead of other factors affecting firms' productivity, infrastructure accounts for 30–60%. Of this result, the electricity sector accounts for 40–80% of the infrastructure effect in half of the SSA countries analysed. Electricity access is not only critical for improving firms' productivity, but it is also indispensable for poverty eradication and thus human development, since it also serves as a solid basis for development of underserved and poor areas without access.

Figure 4. 1: **Access to Electricity and Human Development in SSA countries in 2013**.



Source: UNDP and World Bank Development Indicators databases

This is because once an area is connected to electricity, it would also have access to other amenities of life such as safe potable water, better health conditions, food security, as well as lighting and information. In addition, electricity access would also eliminate the time wasted to collect and use other traditional sources of energy, such as firewood, animal dung, and crop residues for cooking and heating (Goldemberg, 2000), which are established major sources of harmful indoor air pollution (Smith and Mehta, 2003). This shows that those without access not only spend significant portion of their income on energy consumption, but also sacrifice their labour time and health to have energy access. A survey conducted in Burkina Faso find that the poor spend 5.6 and 1.3% of their income on firewood and kerosene consumptions respectively (Gaye, 2007).

The correlation between access to cleaner energy and poverty reduction is corroborated by a number of studies on other developing countries. Barnes et al. (2010) find evidence that increased access to cleaner and affordable energy contributes positively to monetary gains among the poor and leads to better quality of life, such as an improved diet and amount of

food intake and the ability to afford better health and education facilities, among other advantages. Khandker et al. (2012a) also find that providing electricity to rural areas have helped reduce poverty in India. Similarly, access to the central-grid in Bangladesh impacted positively on household income, expenditure and education where the household gain in total income due to electrification was around 21%, with a 1.5 percentage point reduction in poverty per year (Khandker et al., 2012b). Furthermore, access to communal grid electricity have benefited poor households relative to rich households in Vietnam (Khandker, et al., 2013).

This shows that access to affordable and reliable electricity can directly and indirectly benefit the poor through higher productivity and enhanced employment opportunities. Similarly, human development would be enhanced through electricity access which remove constraints enforced on the poor's economic and social wellbeing. In other words, access to electricity can be considered an indicator of human wellbeing (Pinheiro et al., 2011) and a key measurable index of life quality (Pettersson et al., 2012). These studies further emphasise the importance of electricity on human development because a lack of access to basic services would undermine inclusive development. A World Bank (2017) review show that 125 of the 169 policy targets included in the SDGs are interconnected with energy. This represents 74% of the targets and justifies the argument to prioritize energy especially electricity access in developmental policies and agendas.

Some studies have directly assessed the impact of energy access on human development. Kanagawa and Nakata (2008) find a significant correlation between electricity consumption and GDP as well as HDI for 120 countries, and the countries which achieved high electricity consumption per capita, witnessed high economic development. Ghali and El-Sakka (2004) find that per-capita energy and electricity consumption are not only highly correlated with economic development, but also with other indicators of modern lifestyle, which suggest that

more energy that is consumed, especially in the form of electricity, better human wellbeing would be achieved. Zahnd and Kimber (2009) show that electricity access is associated with health, education, social and economic benefits to the people who have previously lived in homes with excessive indoor air pollution.

Furthermore, in India's Assam state, rural electrification has boosted both social and economic development as well as help achieve the poverty reduction goal of the government (Kanagawa and Nakata, 2008). Mazur (2011) provided similar evidence that electricity consumption has improved well-being in less-developed countries, particularly in populous China and India. Burney (1995) find increase in income growth leads to increase in electricity consumption, which is compounded by socioeconomic development, as reflected by increases in literacy, share of industry and urbanization.

Holtedahl and Joutz (2004) studied the link between urbanization rate and electricity access and find two reasons why higher urbanization would lead to higher energy use. First, increased urbanization is accompanied with greater electricity access, since households can easily get connected to the grid. Secondly, households that already had access are likely to increase their consumption because of increased use of existing and new appliances. Wu et al. (2010) by utilising the Lorentz Curve, Gini Coefficient and Theil Indexes, assessed the inequality in energy access and find differences in the economic development levels of countries that are categorised into high, middle and low groups. Pasternak (2000), using a data on the 60 most populous countries in the world examined the relationship between electricity consumption and the HDI. The study finds that a threshold of annual electricity consumption of 4,000 kWh per capita is required to achieve an HDI value of 0.9 or greater.

In a study related to SSA, Dinkelman (2011) compared labour market outcomes in rural communities in South Africa that gained access to electricity before 2001, to those that were yet to be connected. The study finds that the share of households using electric lighting rises

by 23 % and the share of those cooking with wood fall by 4% within five years in areas with access. Further, the results show that due to electrification, women are 13% more likely to participate in the local labour market. Broto et al. (2015) find that show Maputo people found the provision of street lighting to be important for safety, thus creating a welcoming neighbourhood. In a similar study, provision of lighting in areas with access in South Africa was found to improve safety and scare away reptiles from people's dwellings as well as improve access to entertainment thereby improving quality of life the people (Azimoh et al., 2015; Prasad and Visagie, 2006).

Notwithstanding the relevance of the reviewed studies and numerous policies interventions directed towards expanding electricity access in SSA countries, few studies have attempted to assess the impact of electricity provision in terms of human development. More importantly, none of the reviewed studies on the region have directly investigated the impact electricity access on human development using panel data. Similarly, while policy implementations may have led to modest increased in access rates, no evidence has been encountered that showed what has been achieved in terms human wellbeing in SSA countries. Lastly, most of the reviewed studies on are mostly on Asian developing countries and the few on SSA countries are single country case studies (Dinkelman, 2008). Therefore, the study uses a dynamic panel estimator to investigate the impact of electricity access on human development and its three components (life expectancy, income, and education) using a dataset on SSA countries.

4.3. Methodology

4.3.1. Econometric model

A Generalized Method of Moments (GMM) is used to estimate a model to assess the impacts of electricity access on human development in SSA measured through HDI and its three

components. It is postulated that human development (*hdi*) depends on access rate (per capita electricity consumption; *access*) among other factors. The model estimated is given in (5):

$$hdi_{it} = \varphi hdi_{it-1} + \alpha_i + \beta_1 access_{it} + \sum_{q=1}^{Q} \beta_{2q} X_{it} + \beta_3 time + \varepsilon_{it} \quad (5)$$

where *hdi* represents the human development index (or either of its three components: life expectancy, *life*; education, *edu*; or income, *income*) of country *i* at year *t*, while hdi_{it-1} stand for the lagged values of *hdi* (or either of the three components). βs and φ are parameters to be estimated, α_i are country-specific effects and control for time-invariant unobservables and $\varepsilon_{it} \sim N(0, \sigma^2)$, is the stochastic error term, while *time* represents a linear time-trend, which takes into account technological progress. The vector of *Q* control variables (*X*) is introduced to control for some country-specific characteristics and minimize the biases that spur from these specific features. Controls such as corruption (*corr*), trade openness (*trade*), and total expenditures on health (*heaexp*) and education (*eduexp*) as percentages of GDP are also added.

4.3.2. Estimation strategy

As the data on the human development indexes indicate, human wellbeing tends to change over time slowly. Lagged values of the dependent variables (hdi_{it-1}) are included in Equation (5) to capture these changes. Due to the dynamic structure of the model, the pooled OLS estimates of φ is inconsistent when the time span is small (Nickell, 1981). Furthermore, if the electricity access or other control variables and the error term ε_{it} in Equation (5) are not independent, unobserved variables would affect both the dependent variables and regressors, so the estimated coefficient β_1 and β_2 would be biased. This type of bias can be partially dealt with by controlling for fixed effects and time trend, however, if some unobserved variable changes over time and across countries, the problem would appear in the error term

ε_{it}. Therefore, neither the Fixed Effects (FE) estimator nor the Random Effects (RE) estimator would produce consistent estimates in the presence of these dynamics and the endogeneity of regressors.

Moreover, most studies on human developments impacts of electricity access may misestimate the benefits of electrification if endogeneity of human wellbeing is ignored. This is because not only electrification affects human development, but household income can also determine whether or not a household would have access. For example, higher-income households are more willing to get a connection as soon as the grid arrives (particularly if the connection fees are not fully subsidized), and utilities prefer to provide electricity to higher-income communities (Bacon and Kojima 2016).

In order to deal with these methodological issues, a dynamic panel two-step GMM estimator suggested by Arellano and Bover (1995) and Blundell and Bond (1998) that improved on the abovementioned estimators is used. The dynamic GMM estimator is not only appropriate for endogenous regressors that are correlated with past and possibly current realizations of the error term ε_{it}, but also allows for the inclusion of country-specific effects (α_i) to account for time-invariant unobserved heterogeneity, heteroskedasticity, and autocorrelation within individuals, but not across them (Roodman 2009).

The estimator does not rely on difficult and sometimes unreliable instruments as in the case of the Two-Stage Least Squares (2SLS) estimator. This is because the dynamic Difference GMM (Diff-GMM) estimator relies on internal instruments within the panel to instrument for the endogenous regressors. In other words, past values of the regressors and HDI can be used as instruments, thus eliminating the need for external instruments. However, this variant of the dynamic panel estimator would remove the country-specific effects (α_i) and all other time-invariant variables during estimation. As a result, the estimator is noted to perform poorly in the presence of persistent processes because the lagged levels may convey little

information on future changes (Roodman, 2008). In other words, the estimator tends to produce inconsistent estimates since the differencing produces weak instruments.

The System GMM (Sys-GMM) estimator improves on the shortcomings of the Diff-GMM estimator and allows not only for the inclusion of time-invariant regressors – that gets eliminated in the Diff-GMM estimation – but also deal with all other sources of endogeneity. The estimator overcomes the problem of endogeneity of regressors and dynamics by using a potentially large matrix of available instruments and weights them appropriately. The inclusion of extra instruments, however, requires additional moment conditions; thus, the system GMM builds on a system of two equations: the original equation as well as the transformed one. In other words, the estimator works with all sources of endogeneity by treating the model as a system of equations in first differences and in levels thereby instrumenting the endogenous regressors in the transformed equation by lags of their levels, while instrumenting those in the level equation with lags of their first differences. Due to its superiority to other panel data estimators, a dynamic panel System GMM estimator is utilised to estimate Equation (5).

Obtaining unbiased results while using the dynamic System GMM estimator depends on passing two tests. First, the Hansen test for overidentification restrictions which is a joint test of model specification and appropriateness of the instruments vector. Failure to reject the null hypothesis of the test indicates that instruments used in estimation are valid and the model is well specified. The second is the Arellano and Bond (1991) test for serial correlation of the disturbances up to the second order. The appropriate check of the test for serial correlation (AR) relates only to the absence of second-order serial correlation, AR(2), since the first differencing induces first-order serial correlation, AR(1), in the transformed errors.[4]

[4] Results are obtained using the command xtabond2 in Stata. This two-step estimator is developed, implemented

4.4. Data

Dependent variables

A panel data of annual country-specific observations from 49 SSA countries over the period 2002-2013 is used.[5] Table 4.4 presents the descriptive statistics of the variables utilised in this study. The selection of countries and time period is largely determined by data availability especially on electricity access and human development. The dependent variables in the model is the Human Development Index (*hdi-index*) which was developed by the United Nations Development Program (UNDP) in 1990 to provide a yardstick of comparing the progress made by member countries of the United Nations in enhancing human development. In other words, the index was specifically developed to measure the wellbeing of people, as the first HDI publication noted:

> "The real wealth of a nation is its people. And the purpose of development is to create an enabling environment for people to enjoy long, healthy and creative lives. This simple but powerful truth is too often forgotten in the pursuit of material and financial wealth." (UNDP, 1990, p.9).

Human Development Report (HDR) is published annually by the UNDP to report the progress made by member countries, regions and member states in enhancing human development since 1990. At the core of the reports are the progress made in achieving quality of life, education, and a decent standard of living. Hence, the HDI measures human

and explained in detail in Roodman (2009).

[5]SSA countries in the sample are: Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Comoros, Dem. Rep. Congo, Rep. Congo, Cote d'Ivoire, Djibouti, Equatorial Guinea, Eritrea, Eswatini, Ethiopia, Gabon, The Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Reunion, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, Sudan, Tanzania, Togo, Uganda, Zambia, and Zimbabwe. Countries contained in the sample were dictated by data availability especially data on access rates and HDI.

development through three key indicators: longevity, knowledge, and GDP (at Purchasing Power Parity, PPP) per capita.[6] For this reason, the study not only use the HDI index to assess the impact of electricity access but also use the three indexes that make up the HDI in order to investigate the impact of electricity access.

The life expectancy index (*life-index*), which is the health dimension of the HDI, is constructed by expressing life expectancy at birth as an index using a minimum value of 20 years and a maximum value of 85 years. The education index (*edu-index*) is an average of mean years of schooling (of adults) and expected years of schooling (of children), both expressed as an index obtained by scaling with the corresponding maxima. The income index (*income-index*) is based on the GNI (2011 PPP International $) per capita expressed as an index using a minimum value of $75,000. As noted, the data on all these indexes are all taken from the HDI database of the UNDP.

Independent variables

In order to assess the impacts of electricity access on human development, per capita electricity consumption (*comper*) is used as explanatory variable in Equation (5). Although this choice of this independent variable may have some limitations, there are several reasons why it is a better proxy than other two alternative measures commonly used: IEA data on electricity access rates and night-time satellite imagery data captured by the US Defence Meteorological Satellite Program's Operational Linescan System (DMSP-OLS).[7]

The IEA data, which was first compiled in the "World Energy Outlook, 2002", was based on various sources such as countries' self-assessed reports (World Bank and IEA, 2015), which magnifies the sources of errors and thus leads to overestimation of access rates (Min, 2010).

[6] See the technical notes of HDR 2011 on how the HDI was calculated and constructed.

[7] The data is being archived and provided to researchers by the National Oceanic and Atmospheric Administration (NOAA) at its National Geophysical Data Centre.

Another drawback of the IEA data is that, it only indicates the extent of electricity infrastructure provision, and therefore is silent on quality, reliability and whether services has been consumed or not (World Bank and IEA, 2015; Ahlborg et al., 2015).[8]

Similarly, night-time satellite imagery has some serious drawbacks too. For example, the measure includes people without access to electricity services residing in electrified towns (Doll and Pachauri, 2010). As a result, its reliability as an indicator of access rate is weak since it only measures stable outdoor lights, which can be a major problem in SSA countries where there are high incidences of load shedding (World Bank, 2009).[9]

Therefore, using consumption per capita other than connection rates or satellite imagery as the main explanatory variable has the advantage of assessing how consumers were able to translate access to real use, rather than just the physical extension of electricity infrastructures. As result, if there are significant changes in service reliability, it is expected that consumption to be adversely affected. Moreover, as Ahlborg et al. (2015) have noted, using a per capita measure rather than measuring average consumption among the electrified minority has the advantage of comparing development patterns across SSA countries of different population sizes. Furthermore, per capita measures allow for the assessment of whether consumption levels have kept pace with population growth in each country. Data on *comper* is obtained from United Nations energy statistics database.

Control variables

Corruption (*corr*) is included in the model since it has the effect of reducing government expenditure on education and health because social spending would offer less opportunity for rent seeking by public officials (Mauro, 1998). Similarly, Gupta et al. (1998) show that

[8] For further discussion, see Ahlborg et al. (2015). We use this measure of electricity access to check the robustness of our results.

[9] For further shortcomings of this data, see Doll and Pachauri (2010).

corruption reduces the level of social spending, fosters education inequality, lowers secondary schooling, and causes unequal distribution of resources. The control of corruption index obtained from Kaufmann et al. (2010) which is included in the World Bank Governance Indicator Database is utilised. The corruption index, which measures corruption in both public and private sectors, ranges from -2.5 (highly corrupt) to 2.5 (highly clean).

Table 4. 4: Summary Statistics of the Data

Variables	Labels	Unit	Obs.	Mean	Std. Dev.	Min.	Max.
Dependent Variables							
Human Development	*hdi-index*	Index	555	0.47	0.10	0.26	0.78
Life expectancy	*life-index*	Index	576	0.57	0.10	0.32	0.83
Education	*edu-index*	Index	555	0.41	0.12	0.12	0.71
Income	*income-index*	Index	564	0.48	0.14	0.18	0.86
Independent Variables							
Access Rates	*access*	%	576	34.49	25.01	0.01	99.40
Elect. Consumption, Per Capita	*comper*	kWh per capita	574	398.47	740.07	1.62	4,177.50
Control Variables							
Corruption	*corr*	Index	576	-0.64	0.61	-1.87	1.22
Education expenditure	*eduexp*	%	335	17.08	5.80	4.77	37.52
Health expenditure	*healexp*	%	546	5.60	2.27	0.84	13.12
Consumer price	*com-price*	Index	527	87.75	24.14	15.35	218.56
Population growth	*poprate*	%	574	2.52	0.89	-2.63	4.77
Particulate Matter	*pm25*	Micrograms per cubic meter	230	38.43	19.44	9.52	118.31
Globalization Index	*global*	Index	576	46.10	8.80	26.82	71.13
Population Density	*popden*	Inhab./km^2	574	88.43	116.08	2.38	620.03
Political instability	*instab*	Index	586	-0.50	0.95	-3.32	1.20

Government spending on education (*eduexp*) and health (*heaexp*) as percentages of GDP as are used as control variables since these are among the most significant investments by governments to enhance human capital and wellbeing. The role of education and health in enhancing human development has been extensively discussed in the literature. For example, education can enhance economic performance by increasing the efficiency of the workforce, reducing inequality, promoting health, reducing fertility levels, creating better conditions for good governance, and increasing the knowledge and the innovative capacity of an economy

(Aghion et al., 1999; Castelló-Climent and Doménech, 2008; Glaeser et al., 2004; Castelló-Climent, 2008; Benhabib and Spiegel, 1994; Hanushek and Woessmann, 2008). Similarly, increase in health capital reduces the time lost to illness and thus, health allows a more effective performance that increases productivity (Grossman, 1972). Data on both *eduexp* (% of government total expenditure) and *heaexp* (current health expenditure as % of GDP) are from Wold Bank Development Indicators Database.

Another important control variable, the consumer price index (*com-price*) which reflects changes in the cost of living to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly is also used. According to the World Bank (2012), if there are daily increases in the price of consumables, consumers' wellbeing especially of low-income households would be adversely affected. Other studies, such as Lee (2001), Egunjobi (1991) and Todaro (1989), have established a link between population growth and human development. These studies seek to answer questions such as: do rapid population growth make governments struggle to provide essential social services? Will population growth lead to increase in unemployment? Will population growth ensure adequate health care and basic education? Therefore, growth rate of population (*poprate*) is used in the estimations. Data on *com-price* is from Wold Bank Development Indicators Database, while data on *poprate* is from the United Nations, Department of Economic and Social Affairs, Population Division (2018).

Lastly, a measure of air pollution, particulate matter (PM2.5) is include, because of the growing concern about its adverse effects on human development especially as it has been established that children who were exposed to high levels of air pollution are likely to have low levels of education and skills in adulthood (Dieter, 2012). The effects of air pollution on human development may depend on factors such as the type of pollutant and its concentration

level, duration of exposure, and the presence of other pollutants (Vichit-Vadakan et al., 2010).

The main sources of air pollution in SSA countries are fossil fuels, biomass consumption and poor waste management practices (IEA, 2017). Data on PM2.5, measured as percentage of the population who are exposed to ambient concentration of PM2.5 that exceeds WHO (World Health Organization) guideline value, is from Brauer et al. (2017) and is included in the World Bank Development Indicators Database.

In order to check the robustness of the results, three additional regressors are add – globalization index (*global*), population density (*popden*) and political instability (*instab*) – to the human development and its three components equations.

4.5. Results

This section presents and discusses regression results of the human development (*hdi*) and its components (income per capita, *income-index*; life expectancy, *life-index*; and education, *edu-index*) equations using dynamic panel Sys-GMM estimator. The first subsection presents and discusses the coefficient estimates of the HDI equation, while the second subsection presents the coefficient estimates of the life expectancy, education and income equations.

Regression statistics presented at the bottom of the tables with the parameter estimates indicate that all models fit the data well. The AR(1) and AR(2) test statistics indicate that in some of the estimations, there is first order serial correlation, but not at the second order, which evidences the inconsistency of OLS and the appropriateness of using a GMM estimator in the context (Arellano and Bond, 1991). In addition, the Hansen test of model specification and overidentifying restrictions indicates that all models are correctly specified with appropriate instruments. the estimation strategy differs from earlier studies that use static models or case studies on single countries to analyse the impacts of electricity access

on human development in SSA countries (e.g., Dinkelman, 2011).

4.5.1. Human development equation

The results[10] of the two-step Sys-GMM estimates of the HDI equation are presented in Table 4.5. The coefficient estimate of *comper* is positive and significant, suggesting that all things being equal, an increase in electricity access is positively associated with improvement in human development. This result reconfirms Dinkelman's (2011) finding that show how electricity access positively impacted on HDI in South Africa by providing opportunities for self-employment and importantly female self-employment. It is also in line with studies on other developing countries (e.g., Barnes et al., 2010; Klandker et al., 2012; Klandker et al., 2013) that find electricity access enhances human development through increased food intake, improvements in diet, ability to afford education and health through increase in household income and reduction in the number of people in poverty.

Although, Escribano et al. (2008) did not directly assessed the impact of access rates on human development, they find evidence that low electricity access has adversely affected HDI through economic performance in SSA countries. However, the intuition behind their results indicates that lack of access to electricity and unreliability of services have not only constrained the economic performance of SSA countries, but also have adversely affected human development. Thus, consistent with these studies result, the results suggest that electricity access is a key determinant of human development where it has been provided. However, the result differs from those of Madubansi and Shackleton (2007) who reported that after 11-year period of village electrification efforts, fuel wood consumption had not changed in five South African villages. Hiemstra-van der Horst and Hovorka (2008) also find

[10] This results and other subsequent ones in this chapter suffer from lower levels of observations during estimation. This is due to the inclusion of the variable pm in the estimations. After excluding the variable from the estimations there were not significant changes in results even though the number of observations increases to over 500 in some cases.

similar results in the case of Botswana.

Table 4. 5: Two-Step GMM Estimates of HDI Equation

Human Development Index (*hdi-index*)		
Variable	**Est.**	**t-stat.**
hdi-index(t-1)	0.843***	22.23
ln comper	0.007***	3.86
corr	0.004**	1.97
eduexp	-0.001	-1.32
healexp	0.001***	3.79
com-price	-0.001***	-3.20
pm	-0.001***	-3.16
poprate	0.001	0.72
time	0.002***	4.87
intercept	0.143***	4.19
No of obs.		144
No of countries		41
Instruments		30
AR(1) test (p value)		-1.47 (0.141)
AR(2) test (p value)		-1.00 (0.319)
Hansen test (p value)		17.67 (0.609)
Significance code: *** p<0.01, ** p<0.05, * p<0.1		

This shows that if efforts are made to increase electricity access to the 590 million people without basic access (IEA, 2017) in the region, it would not only boost economic performance, but would also enhance human development. For example, expanding electricity to access would help fulfil the ambition of Goal 7 of the SDGs by 2030 of providing universal access to affordable, reliable and modern energy services. In order to achieve sustained level of socio-economic development, Brew-Hammond (2010) noted that SSA countries most effectively mobilisation both domestic and external funding through implementations of innovative policy frameworks that would attract private sector investments.

The estimated coefficient for *healexp* is positive and significant, suggesting that an increase

in government expenditure on and health is associated with an increase in human wellbeing. This result contrasts with Filmer and Pritchett (1997) who find government spending on health did not lead to improvements in health measured as child mortality. However, the result is similar to those obtained by other researchers who find a positive relationship between public spending on health care and human development (e.g., Fan, et al., 2008).

The coefficient for *eduexp* is not significant suggesting that there is no association between government spending on education and human development. This could be explained by low public spending on education by most SSA countries. Public spending on education as share of GDP in most SSA countries is below the 6% threshold recommended by UNESCO (2017). The result is consistent with other studies that find insignificant or a weak link between public spending and educational outcomes (Flug et al., 1998) and differs from Sequiera and Martins (2008). The estimates of both *healexp* and *eduexp* suggest government social spending is an important channel through which SSA countries can enhance human development, therefore increasing it would further boost human development.

Regarding the other control variables, the coefficient of *corr*, is positive and significant suggesting that corruption has adversely affected human wellbeing thus confirming Mauro's (1998) finding that show how corruption reduces government expenditure on education and health. The coefficient of *com-price* is also positive and significant suggesting that increase in cost of living have affected the wellbeing of citizens in SSA countries during the period covered by this study. This result confirms a World Bank (2012) report that shows soaring prices especially of food have held back millions from escaping poverty particularly in Africa and Asia.

The coefficient of *pm* is negative and significant indicating that exposure to air pollution have adversely affected human wellbeing in SSA countries. This is not surprising as about 80% of the population of SSA use solid fuels in cooking and this has been responsible for more than

50% of all deaths from pneumonia in children under 5 years and chronic lung diseases and cancers in adults over the age of 30 (WHO, 2016). However, the coefficient of *poprate* is not significant suggesting that population growth has no effect on human development. The coefficient of *time* is positive and significant signifying that, other things equal, human development has increased over time.

4.5.2. Human development components

The results of the impact of access rates on HDI's three components (life expectancy, education and income per capita) are presented in Table 4.6. In columns 1, 3 and 5, the coefficient estimates of *comper* are positive and significant, and confirm the result of the HDI estimation in Table 4.5. In other words, the results suggest that electricity access have positively boosted education, life expectancy and income per capita of SSA countries during the period covered by the study. Some studies have found evidence on the association between electrification and the three components of HDI. On the educational impact, Nanhuni and Findes (2003) find evidence that in Mali, lack of electricity access has led children to spend more time in resource collection and thus reduced the likelihood of school attendance, especially among girls. Mapako (2010) shows that access to reliable and affordable electricity for cooking has reduced collection times significantly in South Africa, and this has been translated into increased time for education, encouraged school attendance and reduced dropout rates (UNEP, 2008).

Similar findings were established on the relationship between electricity access and health, and income. On the impact of access rates on income, Khandker et al. (2013) find evidence that households and small business incomes increased after getting connected to electricity, while Dinkelman (2011) finds evidence that in Kwazulu-Natal of South Africa, households' employment increased especially of women after electricity was extended to community.

The coefficient estimates of *eduexp* is significant in columns 1, 3 and 5, however, the public spending on education have negatively affected both income and health (columns 1 and 3), while positively affecting education (column 5). These estimates suggest that government spending on education has reduced income per capita and led to poor health outcomes but have boosted educational outcomes. The negative impact of education expenditure on health and income may not be unconnected with lower resources devoted by SSA governments to education in their national budgets. For example, most of SSA countries do not meet the international benchmark of 15% to 20% of GDP as education expenditure (UNESCO, 2012).

When enough resources are not provided to educate the growing population in SSA countries, it would lead to lower income and poor health outcomes due to correlation between education and income/health. For instance, it has been established that an additional 4 years of education lowers 5-year mortality by 1.8 percentage points; it also reduces the risk of heart disease by 2.16 percentage points, and the risk of diabetes by 1.3 percentage points (Cuter and Lleras-Muney, 2006). However, government expenditure on health have positively impacted on all three components of human development as indicated by the coefficient of *healexp*. These results show that life expectancy, education and income are all responsive to government expenditure on health.

The coefficient of *corr* is significant and positive in columns 1 and 5, while it is not significant in column 3. These estimates suggest that corruption has adversely affected income growth and education, while it has no effects on life expectancy. All three coefficient estimates of *pm* are significant and negative thus confirming the earlier result about human development effects of air pollution. However, the price index (*com-price*) has only negatively affected educational outcomes, while it has no effect on both life expectancy and income. The coefficient of the time trend (*time*) is significant in life expectancy and

education, but not in the income equation. The coefficient of *poprate* is significant and positive in columns 3 and 5, while it is not significant in column 1. The estimate suggest that population growth have boosted life expectancy and education, but it had no effect on income.

The results on the impact of electricity access on the components of human development in Tables 4.6 have further amplified the earlier result in Table 4.5 although there are changes in the signs and estimates of some control variables. Overall, the results in Tables 4.5 and 4.6 indicate the importance of infrastructure provision especially electricity on human development in SSA countries.

Table 4. 6: Two-Step GMM Estimates of HDI Components Equations.

	Human Development Index (*hdi*) Components					
	Income Index (*income-index*)		**Life Expectancy Index (*life-index*)**		**Education Index (*edu-index*)**	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Variables	**Est.**	**t-stat.**	**Est.**	**t-stat.**	**Est.**	**t-stat.**
income-index (t-1)	0.964***	102.06				
life-index (t-1)			0.865***	68.94		
edu-index (t-1)					0.855***	18.39
ln comper	0.002***	3.14	0.006***	3.90	0.010***	3.39
Corr	0.007**	2.49	-0.004	-1.62	0.008**	2.04
Eduex	-0.001***	-4.70	-0.001**	-2.48	0.001**	2.48
Healexp	0.001**	2.37	0.001***	7.61	0.001*	1.91
compri-index	0.001	1.49	0.001	0.99	-0.001**	-1.98
Pm	-0.001**	-2.56	-0.001***	-6.38	-0.001***	-2.67
poprate	0.001	0.14	0.008***	3.22	0.003*	1.66
ln *gnp*			0.002*	1.95	0.003**	2.12
Time	-0.001	-0.02	0.001***	4.50	0.001**	2.00
intercept	0.039***	5.90	0.100***	5.37	0.099***	2.62
No of obs.		144		144		144
No. of countries		41		41		41
Instruments		35		35		35
AR(1) test (p value)		-2.38 (0.017)		1.37 (0.172)		-0.40 (0.688)

AR(2) test (p value)	1.07 (0.286)	-1.45 (0.148)	-1.61 (0.108)
Hansen test (p value)	24.64 (0.483)	23.08 (0.515)	27.49 (0.282)

Significance code: *** p<0.01, ** p<0.05, * p<0.1

4.5.3. Robustness Analyses

It is possible that the obtained results on the impact of access rates on HDI and its three components are affected by omitted variables bias, or the measure of access used to estimate the Equation 1. Therefore, the robustness of the obtained result is investigated. First, three additional regressors are added to the HDI equation and the components equations, one at a time, to see whether the earlier obtained result in Tables 4.5 and 4.6 change significantly. Lastly, we another measure of access rates (percentage of total population with electricity access) to re-estimate the all the models to see if results are influenced by the choice of the access variable.

4.5.3.1. Additional Regressors

According to Todaro (1989), it is not only the sheer number of people that affects human development, but its distribution or concentration also has an impact. This is because as the size of population rises, especially in areas that lack access to infrastructure, it would trigger migration to areas with access or people will migrate from rural to urban. This would lead to concentration of the population in geographic pockets within a country. Therefore, the annual population density, which is in people per square kilometres of land area is included to all the estimations. Data on *popden* is from the World Bank Development Indicators.

Some studies have established a relationship between globalization and human development (see Sapkota, 2011), thus the level of globalization of SSA countries is included in the HDI and its three components equations. The KOF globalisation index that measures the economic, social and political dimensions of globalisation covering 24 variables over time, first developed by Dreher (2006) and recently updated by Gygli et al. (2019) is used.

Finally, some studies (e.g., Collier and Hoeffler, 2004; Justino and Verwimp, 2006) have argued that political instability and conflict negatively affect human development. For example, where wars and conflict have erupted, economic activity would be severely constraint due destruction of infrastructure, environmental degradation, restriction export and imports among many. As a result, human development would be constrained. An index of political violence and/or politically motivated violence, including terrorism (*instab*) is included to all estimations. Data on the variable is obtained from Kaufmann et al. (2010) which is included in the World Bank Governance Indicator Database.

Table 4. 7: Two-Step GMM Estimates of HDI Equation – Additional Regressors.

Human Development Index (*hdi*) - Additional Regressors						
	Population Density		**Globalization**		**Political Instability**	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Variables	**Est.**	**t-stat.**	**Est.**	**t-stat.**	**Est.**	**t-stat.**
hdi-index (t-1)	0.906***	32.57	0.905***	37.64	0.923***	33.90
ln comper	0.003**	2.42	0.005***	3.13	0.003**	2.15
Corr	0.003*	1.77	0.003*	1.76	0.009***	3.65
Eduex	-0.001	-0.90	-0.001	-0.36	-0.001***	-2.83
Healexp	0.001***	6.54	0.001***	4.30	0.001*	1.88
compri-index	-0.001***	-3.20	-0.001**	-2.53	-0.001**	-2.26
Pm	-0.001***	-3.03	-0.001**	-2.46	-0.001***	-3.17
poprate	0.001	0.05	0.001	1.24	0.002***	3.15
ln popden	-0.001**	-2.33	-0.001**	-2.14	-0.001	-0.75
global-index			0.001	0.60	0.001**	2.47
Instab					-0.002**	-2.15
Time	0.001***	4.81	0.001***	4.47	0.001***	3.30
intercept	0.077***	3.38	0.089***	3.82	0.058***	2.65
No of obs.		144		144		144
No. of countries		41		41		41
Instruments		36		37		38
AR(1) test (p value)		-1.82 (0.069)		-1.87 (0.061)		-0.98 (0.327)
AR(2) test (p value)		-0.89 (0.371)		-0.81 (0.415)		-0.94 (0.349)
Hansen test (p value)		27.69 (0.322)		21.98 (0.637)		18.05 (0.840)

Significance code: *** p<0.01, ** p<0.05, * p<0.

The results of the robustness test are presented in Tables 4.7, 4.8, 4.9 and 4.10. Columns 1, 3, and 5 in the tables present the coefficient estimates of *comper* and the rest of the variables when the *popden, global* and *instab* respectively, are added, one at a time, as regressors to the equations. Coefficients of access rates remain significant and with the right signs regardless of the additional regressors included in the equation. These estimates suggest that the access rate variable is not acting as proxy for some omitted regressors which should have been included in the global HDI or the other three equations.

Table 4. 8: Two-Step GMM Estimates of Income Equation – Additional Regressors.

Income Index (*income-index)* - Additional Regressors						
	Population Density		**Globalization**		**Political Instability**	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Variables	**Est.**	**t-stat.**	**Est.**	**t-stat.**	**Est.**	**t-stat.**
income-index (t-1)	0.906***	46.60	0.936***	64.04	0.922***	52.76
ln comper	0.002**	2.34	0.006***	5.05	0.004***	3.26
Corr	0.014***	3.56	0.007***	3.94	0.010***	2.76
Eduex	-0.001	-1.28	-0.001***	-3.92	-0.001***	-4.25
Healexp	0.001***	2.89	-0.001***	-4.40	0.001***	2.69
compri-index	-0.001*	-1.75	0.001	1.15	0.001	1.09
Pm	-0.001**	-2.01	-0.001*	-1.93	-0.001***	-2.66
Poprate	-0.003**	-2.24	0.003***	3.18	0.001	0.78
ln popden	-0.003**	-2.51	-0.001	-0.55	-0.002***	-2.70
global-index			0.001***	3.42	0.001	0.32
Instab					0.001	0.20
Time	0.001***	3.46	-0.001	-0.06	0.001	0.45
Intercept	0.088***	4.25	0.073***	4.89	0.089***	4.38
No of obs.		144		144		144
No. of countries		41		41		41
Instruments		36		36		37
AR(1) test (p value)		-2.35 (0.019)		-1.95 (0.051)		-2.43 (0.015)
AR(2) test (p value)		1.44 (0.149)		1.53 (0.127)		0.22 (0.824)
Hansen test (p value)		26.67 (0.372)		22.27 (0.563)		21.93 (0.583)

Significance code: *** p<0.01, ** p<0.05, * p<0.1

Table 4. 9: Two-Step GMM Estimates of Life Expectancy Equation – Additional Regressors.

Life Index (*life-index)* - Additional Regressors						
	Population Density		Globalization		Political Instability	
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	**Est.**	**t-stat.**	**Est.**	**t-stat.**	**Est.**	**t-stat.**
life-index (t-1)	0.832***	58.29	0.832***	55.61	0.970***	76.66
ln comper	0.008***	6.51	0.008***	4.85	0.001*	1.83
Corr	-0.003	-1.64	-0.002	-1.40	0.003*	1.84
Eduex	-0.001**	-1.98	-0.001**	-2.23	0.001***	4.90
Healexp	0.001***	7.17	0.001***	6.63	0.001***	4.64
compri-index	0.001*	1.96	0.001	1.63	-0.001	-0.78
Pm	-0.001***	-5.46	-0.001***	-5.23	-0.001***	-2.73
Poprate	0.006**	2.51	0.007***	2.77	0.001	0.53
ln gnp	0.001	0.08	0.001	0.18	-0.001	-1.18
ln popden	0.006***	3.12	0.005***	2.80	-0.001*	-1.81
global-index			-0.001	-0.01	0.001	1.12
Instab					-0.001*	-1.79
Time	0.001***	6.16	0.001***	5.98	0.001	0.59
Intercept	0.126***	7.37	0.131***	4.26	0.033**	2.35
No of obs.		144		144		144
No. of countries		41		41		41
Instruments		36		37		40
AR(1) test (p value)		1.75 (0.081)		1.61 (0.108)		0.83 (0.404)
AR(2) test (p value)		-0.69 (0.493)		-0.84 (0.400)		-0.34 (0.733)
Hansen test (p value)		23.68 (0.480)		24.16 (0.452)		20.65 (0.760)

Significance code: *** p<0.01, ** p<0.05, * p<0.1

Table 4. 10: Two-Step GMM Estimates of Education Equation – Additional Regressors.

Education Index (*edu-index)* - Additional Regressors						
	Population Density		Globalization		Political Instability	
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	**Est.**	**t-stat.**	**Est.**	**t-stat.**	**Est.**	**t-stat.**
edu-index (t-1)	0.825***	17.31	0.798***	19.35	0.804***	20.05
ln comper	0.015***	4.59	0.015***	4.44	0.012***	3.50
Corr	0.010***	2.63	0.011***	2.76	0.012***	2.87
Eduex	0.001**	2.26	0.001**	2.34	0.001**	2.49
Healexp	0.001**	1.99	0.001**	2.09	0.002**	2.10
compri-index	-0.001**	-2.21	-0.001**	-2.46	-0.001***	-3.59
Pm	-0.001***	-3.09	-0.001***	-4.28	-0.001***	-5.28
Poprate	0.005**	2.16	0.004*	1.88	0.004**	2.07
ln gnp	0.004***	2.71	0.004***	3.06	0.003**	2.14
ln popden	0.002	1.41	0.002	1.63	0.002	1.33
global-index			-0.001	-1.28	-0.001	-0.60
Instab					-0.004**	-2.00
Time	0.002**	2.23	0.002***	3.21	0.003***	4.22
Intercept	0.127***	3.25	0.166***	3.94	0.156***	3.79
No of obs.		144		144		144
No. of countries		41		41		41
Instruments		36		37		38
AR(1) test (p value)		-1.09 (0.926)		0.12 (0.907)		0.69 (0.490)
AR(2) test (p value)		-1.52 (0.129)		-1.58 (0.113)		-1.48 (0.139)
Hansen test (p value)		25.88 (0.359)		26.64 (0.321)		25.68 (0.370)

Significance code: *** p<0.01, ** p<0.05, * p<0.1

4.5.3.2. Alternative measure of access rates

The results are based on the United Nations electricity consumption data. It is possible that the obtained results were driven by this choice of data. In order to investigate this possibility, an alternative measure of access rates (*access*), which is percentage of totally population with electricity access from the World Bank development indicators database is used. The result of Sys-GMM estimates of using the World Bank index is presented in Tables 4.11 and 4.12.

The coefficient of *access* is positive and significant in both tables, suggesting that electricity access, when proxied by the World Bank access rate has also a significant positive impact on human development. The estimates of the coefficient for *access* in the two tables show the relationship between electricity access and human development when additional regressors are added to the model. The inclusion of the other regressors do not affect the statistical significance of the estimates of the coefficient for access rates.

Table 4. 11: Two-Step GMM Estimates of HDI Equation-using access rates

Human Development Index (*hdi-index*)		
Variable	**Est.**	**t-stat.**
hdi-index(t-1)	0.912***	36.10
access	0.001***	4.66
corr	0.002**	2.14
eduex	0.001	0.08
healexp	0.001***	3.22
com-price	-0.001***	-3.81
pm	-0.001***	-3.40
poprate	0.001	0.05
time	0.001***	4.01
intercept	0.041***	3.32
No of obs.		144
No of countries		41
Instruments		40
AR(1) test (p value)		-1.84
		(0.066)
AR(2) test (p value)		-0.79
		(0.431)
		32.61
Hansen test (p value)		(0.340)
Significance code: *** p<0.01, ** p<0.05, * p<0.1		

Table 4. 12: Two-Step GMM Estimates of HDI Components Equations-using access rates

Human Development Index (*hdi*) Components						
	Income Index (*income-index*)		Life Expectancy Index (*life-index*)		Education Index (*edu-index*)	
	(1)	(2)	(3)	(4)	(5)	(6)
Variables	**Est.**	**t-stat.**	**Est.**	**t-stat.**	**Est.**	**t-stat.**
income-index (t-1)	0.940***	104.95				
life-index (t-1)			0.921***	54.38		
edu-index (t-1)					0.964***	56.57
Access	0.001***	2.71	0.001***	2.69	0.001**	2.35
Corr	0.004***	4.94	0.004***	2.82	0.003**	2.46
Eduex	-0.001***	-8.76	-0.001***	-4.63	-0.001***	-6.16
Heaexp	0.001	0.93	0.001	1.49	0.002***	9.09
compri-index	-0.001*	-1.90	0.001**	1.99	0.001	0.18
Pm	-0.001***	-3.00	-0.001***	-4.44	-0.001***	-3.20
Poprate	-0.002***	-2.75	0.004***	3.16	0.007***	7.22
ln gnp			-0.004***	-5.53	-0.001**	-2.17
Time	0.001**	2.03	0.001***	3.98	0.001	0.44
Intercept	0.041***	6.83	0.093***	7.59	0.011	1.02
No of obs.		144		144		144
No. of countries		41		41		41
Instruments		40		38		39
AR(1) test (p value)		-2.32 (0.020)		1.75 (0.079)		-2.01 (0.044)
AR(2) test (p value)		1.38 (0.166)		-1.05 (0.295)		-1.63 (0.102)
Hansen test (p value)		28.38 (0.550)		25.16 (0.566)		27.27 (0.503)

Significance code: *** p<0.01, ** p<0.05, * p<0.1

4.6. Conclusion

Provision of access to electricity especially to rural and deprived areas is important for enhancing human development through increasing access to healthcare, quality education and improve income growth. Due to the recognition of its importance, SSA have implemented various policies at national and multilateral levels to increase access to unserved groups of the population. Although, there are some modest improvements in improving access rates after these policy interventions, electrification rates have remained low because the rate of expansion has not kept pace with the population growth. There is also disparity between urban and rural areas, with rural areas being mostly unserved.

These have led some to question the socio-economic benefits of policies implemented to increase electricity access. Despite these scepticisms, there is a limited evidence on the impacts of electricity access on human development on the region. This study fills this gap in the literature by using panel data on 49 SSA countries and a dynamic panel estimator to investigate the effects of electricity access on human development.

The result shows that access to electricity has a positive and significant effect on human development. The chapter also find a positive and significant effects of access rates on the three individual components of the HDI. These findings amplify the socio-economic benefits expanding electricity to the estimated 588 million people that lack access. In other words, extending electricity services to those without access will lead to improved economic performance of SSA countries by improving educational, health and income outcomes.

This finding adds to the body of evidence that stress the importance of infrastructure on human development. It can also serve as an important reference for policy makers while designing policies for poverty reduction and inclusive economic development. This is because, connecting the estimated 588 million people to electricity would serve as one of the most important steps towards reducing poverty and achieving inclusive development

especially the SDGs. The results are robust after controlling for other variables that also have impacts on human development.

Future research should investigate the effect of electricity access other social indicators such as income inequality, gender and poverty where data are accessible. Factors such as these are among some the major challenges currently confronting SSA countries. Similarly, future research should also investigate the difference between SSA countries with and without reformed electricity sectors in terms of human development. This would further enhance the understanding of what has been achieved or otherwise of the nearly three decades of electricity sector reforms in the region.

Chapter 5: Conclusions

5.1. Introduction

This thesis contributes to the understanding of the influence of corruption on economic development of SSA countries. The introduction chapter identified important consequences of high corruption levels and their determinants, which have constrained the economic development of SSA countries. The chapter also shows how corruption distorts economic performance through a less explored but important component of economic development – i.e., the electricity sector. Although, the evidence on the effects of electricity on economic development is mixed, the lack of access to reliable electricity supply constitutes a brake on SSA government aspirations for economic development. This is reinforced by the awareness that electricity is critical for socio-economic development through efficient lighting (Fouquet, 2008), information and communication technologies, and increased productivity in manufacturing (Kander et al., 2014). Therefore, where electricity has been provided, income has increased, and health and educational outcomes have improved.

Corruption can cripple economic development by containing efforts to extend electricity to the millions without access in the region and inhibiting the efficiency of the sector. In order to mitigate these adverse effects of corruption and to increase efficiency and access rates, SSA countries have been implementing electricity sector reforms for more than two and half decades. Although, almost all countries of the region have implemented reforms, the extent of these reforms among them has differed. The differences were due to country-specific conditions, quality of institutions, and political preferences related to the reform agenda. In other words, due to a number of factors, not all countries have succeeded in implementing all aspects of the ESR advocated by reformers. For example, only 50% of the countries in the region have established IRAs, six countries have unbundled their state-owned utilities, only one has introduced a transitional electricity market, and significant number of countries have

introduced some form of private sector participation into their electricity markets.

Each of these aspects of the reform model has been noted to have some corruption reducing potential. For example, the unbundling of the hitherto state-owned utilities serves to identify different sources of inefficiencies that constrain performance while competition among the unbundled units gives consumers freedom of choice and escape from corruption associated with the state-owned monopolist privatised firms as residual claimants have incentives to close all sources of inefficiencies including those related to corruption, and the creation of IRAs safeguards smaller firms from dominant firms, avoids collusions among firms, and safeguards firms from government corruption and consumers from exploitations.

Despite each of the reform elements being infused with these corruption reducing potentials, no study has examined whether SSA countries have succeeded in reducing the negative association between corruption and performance through reforms. Neither is there a study that has empirically assessed whether reductions in the performance constraining effects of corruption have benefited SSA countries in terms of efficiency, access rates and income improvements. The investigation of these limitations underlines the analyses in this thesis. In other words, this thesis contributes to efforts aimed at understanding how well-designed micro level reforms reduce the negative effects of macro level institutional deficiencies such as corruption on micro and macro performance indicators such as electricity sector performance and economic development.

The next section discusses whether the main research questions of the thesis highlighted in each of the three empirical chapters has been answered. Next, some policy implications derived from the results of the three main chapters are highlighted. The third section provides some key policy suggestions for SSA countries that considers implementing or redesigning a reform programme in its electricity market. A discussion on the limitations of the research

constitutes the fourth section. The final section discusses what has been done and what still needs to be done.

5.2. Answers to main research questions

Chapter 2 presents an econometric analysis of the effect of corruption on three indicators of electricity sector performance: technical efficiency, access rates, and GDP per capita. The indirect effects of corruption on these indicators were also considered through how reform implementations such as the creation of IRAs and private sector participations amplify or mitigate the relationship between corruption and electricity sector performance. The results show that levels of corruption in SSA countries are important performance determinants of all three indicators.

Specifically, the results show that perceived corruption levels have an adverse and statistically significant effect on the three performance indicators – i.e., technical efficiency, access to electricity, and GDP per capita. However, in countries where independent regulators have been created, there has been an increase in access to electricity while technical efficiency has declined. In SSA countries where private sector investments have poured in, there has been improvements in economic performance, while there are no changes in electricity access and technical efficiency.

The analysis on how reforms implementations determine the relationship between corruption and electricity sector performance shows that SSA countries that created independent regulators have reduced the adverse effects of corruption on technical efficiency, amplified the adverse effects of corruption on electricity access, and failed to mitigate the often-cited negative association between corruption and income level. The results also show that private sector participation has reinforced the influence of corruption on income while private

participation has no impact on the association between corruption and electricity access as well as between corruption and technical efficiency.

Chapter 3 investigates the performance of reforms in the context of government political ideology due to the realization that performance is not only constrained in SSA countries by corruption alone, but also by political factors. The link between the political institutions and electricity sector is through the independent regulatory agencies created as part of the reforms to depoliticise electricity price-setting and encourage private sector investment through transparent and predictable decisions. Politicians can fill positions in these regulatory agencies with political and financial allies thereby interfering in regulatory functions to advance the agendas of their political parties. Such interferences lead to IRAs designing poor, unpredictable, non-credible, and inconsistent decisions thereby constraining performance.

The findings show that access rates and installed capacity have improved in SSA countries post the establishment of independent regulatory agencies irrespective of ideology. In other words, government ideology does not matter if there are no intrusions into regulatory functions or if IRAs are allowed to exert their regulatory powers. However, there are no significant differences between SSA countries without IRAs/with different government ideologies on their desires to increase installed capacity. This shows that economic or social policy orientations of SSA governments does not differ in terms of installed capacity improvements.

However, there are differences in terms of installed capacity improvements when SSA governments driven by ideological motives interfere in regulatory functions. The results show that independent regulation in left-wing governments reduces installed capacity relative to governments with centrist governments, while regulation in right-wing governments boost improvements in installed capacity relative to centrist governments. The differences in

generation capacity improvements, show that interventionist policies such as government financed provision of electricity and sheltering of utilities from competition tends to be less efficient compared to services provided by private utilities in competitive electricity markets.

On access rates improvements by countries with different political ideologies, access to electricity are lower in countries with right-wing governments, while there are no significant differences between left-wing and centrist governments in extending access to those without services. In other words, the results indicate that SSA countries with right-wing governments motivated by beliefs that governments should minimise their involvement in the economy, tend to spend less on provision of electricity relative to countries with left or centrist governments. However, the opposite happens when regulation happens in left-wing governments. Left-wing governments constraint IRAs' efforts to incentivise utilities to increase access rates despite increasing access to the poor and underserved being one of their important social objectives. In contrast, there is no significant differences between governments with right-wing and centrist governments in terms of access rate improvement despite the perceptions that right-wing governments do not have incentives to build electricity supply infrastructures to extend services especially to unprofitable and poor areas.

In chapter 4, extends the findings of chapter 2 and 3 and show how improvements in access rates post electricity sector reforms have impacted human development. The motivation is that if the aim of any public policy implementation such as ESR is to enhance citizens' welfare, then increased access rates should be expected to bring positive socio-economic benefits. The chapter analyses what has been achieved by expansion of access rates in SSA countries in terms human development post reforms and other policies implemented.

There are some countries that provide evidence of wellbeing improvements in places where electricity services have been provided (e.g., Davis, 1998; Karekezi and Majoro, 2002; Kirubi

et al., 2009; Spalding-Fecher, 2005). However, other similar studies have questioned the social benefits of policy interventions such as ESR (Auriol and Blanc, 2009), especially as 80% of the region's population rely on traditional use of biomass to meet their energy needs (Hancock, 2015). Similarly, Eberhard et al. (2011) argued that expansion of access rates have not benefited the poor in SSA countries, rather it has been skewed strongly towards higher income households and urban areas since privatised utilities do not have incentives to extend services to poor and unprofitable areas (Transnational Institute, 2002; Victor, 2005).

Moreover, there has been extensive policy discussions on efforts to increase access rates in SSA countries by multilateral institutions, governments and private bodies, yet the human development impacts of electricity access relevant to SSA countries has been under-explored empirically. Therefore, chapter 4 examines these arguments through a macro level cross-country approach. Specifically, a panel data on SSA countries was used to analyse the effects of improved electricity access on the HDI and its three different components.

Findings from the analyses show that there are significant positive effects of increased access rates on human development in SSA countries. Similarly, the chapter find positive and significant effects of increased access rates on the three individual components of the HDI. In other words, increased access rates have boosted life expectancy, educational outcomes and income in SSA countries. These results are robust after controlling for additional variables that have effects on HDI and its three components and using a different measure of access rates.

5.3. Policy implications of results

Although, corruption levels tend to be high in SSA countries, an examination of the various channels through which it affects economic development can help point to the right policies that will mitigate its effects. As discussed in chapter 1, there are channels such investments, human capital, and income inequality through which corruption affects economic

development. The findings of chapter 2 suggest that policies such as electricity sector reforms help mitigate negative economic performance effects by reducing its effects on electricity sector performance. One policy implication of chapter 2 is that, it highlighted the importance of setting up of an independent regulator that is transparent, fair, and accountable with the capacity for producing credible and predictable policies and commitments to cost-reflective tariffs and protection of consumer interest.

Establishing an institutional body would not only help reduce uncertainties surrounding issues related to market access, tariffs, and revenues but would also help improve the overall governance of the sector. Setting up of regulators helps reassure foreign investors who are concerned with political corruption in SSA governments, that the independent regulator would safeguard their investments. This is because the regulator reduces the need for risk mitigation measures such as World Bank guarantees, ring-fencing of revenues accruing to off-takers and other measures required by investors when investing in SSA countries' power markets. Thus, by serving as a risk mitigator, the regulator would help attract the crucial investments needed to upgrade and build new transmission and distribution infrastructures and increase generation capacities thereby improving the overall performance of the sector.

The importance of an independent regulator was further emphasised by the findings in chapter 3. Although not explicitly stated, politicians furthering their private agendas (e.g., corruption) or policies of their political parties will intrude into regulatory functions and thereby constraint electricity sector performance. Reducing intrusion into regulatory functions especially by left-wing SSA governments will signal to investors that regulatory decisions are not politicised and thus help attract private investments needed to increase generation capacity and expand access rates. Increasing generation capacity and access will have fulfil one of the social policy objectives of left-wing governments that aimed at

improving the socio-economic conditions of the poor in SSA countries. Therefore, the results suggest that left-wing governments can increase the growth rate of income by reducing interference in IRAs functions.

Chapter 3 results do not indicate that only SSA governments with left-wing governments may interfere regulatory functions, however, the adverse effects of regulatory interferences are severe in countries with left-wing governments. Thus, the results suggest SSA countries with different ideologies should pursue different policies to strengthen the independence of IRAs as a means of improving efficiency and access rates. While strengthening the independence of IRAs in left-wing governments may be critical for increasing capacity and access rates, it may not be as critical for right-wing or centrist governments, especially in increasing capacity. Then giving more independence to IRAs or not interfering in their functions in SSA countries by the same proportion will not only increase capacity and access, it will also help narrow the gap among the countries with different ideologies, since SSA countries with low installed capacity and access rates will benefit the most by boosting the independence of IRAs.

Chapter 4 further amplifies the findings of earlier studies on the positive impacts of electricity access on socio-economic wellbeing especially on the poor. Thus, chapter 4 findings further stress the importance of both public and private investments in building and upgrading electricity supply networks that will help increase the number of people with electricity access. This is because, connecting the estimated 588 million people with access in the region to electricity would serve as an important step towards reducing poverty and achieving inclusive development especially the SDGs.

5.4. Policy recommendations

The main policy recommendations from the three empirical chapters are as follows:

- SSA countries or any developing country that is yet to implement or at earlier stages of electricity sector reforms should recognise the underlying differences between reforms in developed countries and developing countries. Therefore, SSA countries should pay attention to their local conditions such the size of their electricity markets, income levels, level of electricity access, and macroeconomic conditions among others before adopting and implementing electricity sector reforms.

- More importantly, late reformers should note that institutions matter. In other words, SSA countries yet to implement or at early stages of reforms, should take into consideration institutional factors such governance, vested political interests, competition among political parties, and citizens' perceptions of the role of government, among others, before deciding which aspect of reforms to implement and at what time to do that.

- Related to the above, governments should realise that not only their political opponents can hinder reform implementations, but also other strong and vocal anti-reform interest groups such labour unions and managements of the reformed targeted state-owned utilities will curtail the reforms process. Therefore, extensive public awareness campaign should present the objectives and benefits of the reforms. Furthermore, since the political and economic conditions of interest groups will substantially be affected by the reforms, SSA countries should implement reforms under appropriate political conditions with the support of interest groups and citizens.

- SSA countries receiving advise from multilateral bodies such as the IMF and the World Bank on electricity sector liberalization, should make the roles of these multilateral bodies less visible to avoid creating the perception that the reforms are imposed by foreign bodies.

- SSA governments should make expanding access to modern electricity services part of their national development priorities. Other policies apart from electricity sector reforms should also receive high political commitments aimed at accelerating efforts for integrating other sources of energy such as renewables to reduce the energy poverty bedevilling countries of the region. Political commitments should be translated into national energy plans backed by adequate financial and technical plans that will also make the country attractive to foreign investors.

- Rural electrification based on decentralised solutions should be pursued by SSA countries. Decentralised systems such as mini-grids and setting them up in rural areas have the potential to reduce dependence on consumptions of biomass by the majority rural poor in SSA countries. Increasing access to electricity through rural electrification would boost health, educational, and income outcomes.

5.5. Limitations of the research

The research presented in this thesis has some limitations that must be acknowledged. Notwithstanding, I believe that none of the identified limitations undermine the results. The potential limitations of the analyses are the endogeneity of regressors, the limitation of datasets, and the use of dummy variables as proxies for reforms and institutional variables.

In order to address endogeneity concerns a dynamic panel GMM model developed by Arellano and Bover (1995) and Blundell and Bond (1998) was used due to its potentials for producing consistent estimates in the presence of endogeneity of regressors, unobserved country fixed effects and dynamics. Notwithstanding, although this estimator is superior to other alternative estimators, it has its limitations. First, the estimator relies on the lags of the dependent and regressors for identification. Therefore, there is the potential problem of weak instruments, which could become larger as the number of lags of the instrumental variables

increases Thus, increasing the instruments' lags due to the intuition that reforms have long passthrough years to have effects, may make them more exogenous, but may also make them weaker. Although, weak instruments do not appear to drive the results in this thesis, this may be a more important issue to be considered in other research.

Similarly, in the analyses it is assumed that errors are serially uncorrelated, but this assumption may not hold for all variables. Additionally, as Griliches and Hausman (1986) have noted, using panel data estimators such dynamic GMM estimator, the bias resulting from errors in variables may be magnified. Since the estimator relies, at least partially on first-differencing, the GMM estimator may not eliminate measurement error bias unless strong and difficult to verify assumptions are made about serial correlation in the measurement error (Wintoki et al., 2012). Furthermore, the use of lags as instruments relies on an important assumption that should be noted by researchers. This is because since the GMM methodology assumes weak rational expectations (Muth, 1961; Lovell, 1986), then future unexpected changes in either of performance variables in the three chapters are purely an expectational error.

This implies that the empirical model includes every regressor that could conceivably jointly affect both performance (dependent variable) and the regressors (Hansen and Singleton, 1982). Since proxies mostly use in the analyses, this is unlikely to be the case. It is possible that any cross-sectional regression of, especially of the reform dummies, on electricity sector performance and human development to be misspecified and that there are omitted time-varying unobserved regressors that affect both reforms and performance. Thus, researchers should be careful with relying on the statistical tests used to examine the validity of the lagged instrument set in justifying their use of dynamic GMM panel data estimation.

Notwithstanding these limitations, misspecification problems are likely to be more

pronounced in OLS and fixed-effects estimations. Moreover, these estimators are generally not accompanied by specification tests. Therefore, although occasionally the specification tests accompanying the dynamic GMM estimator could be weak, the estimator dominates the OLS or fixed-effects estimation when making inference when the underlying economic process is dynamic. Lastly, the dynamic panel GMM estimator does not solves all endogeneity problems. Future research should use natural experiments or use strictly exogenous instruments for identifying the effect of reforms on performance. However, given the infrequent occurrence of natural experiments, such as unexpected regulatory changes, and the relative difficult of identifying and selecting exogenous instruments, inference from electricity reform research may continue to rely on secondary data. In this regard, the three chapters of the thesis contribute to the literature by providing economic justification for the use of dynamic GMM panel data estimation in electricity sector performance research discussing the conditions under which the GMM estimator improves inference beyond the OLS and fixed-effects estimators.

The second shortcoming relates to the limits of the data sets. In the first, second, and third empirical chapters, the samples are composed of 47, 45, and 49 on SSA countries, respectively, for which I succeeded in obtaining data on all variables to analyse the models. The dependent variables and regressors used in the three empirical chapters could be over- or under-estimated if countries use different conventions, classifications, and methodologies while compiling on them. For example, the same definition of access rate may not be used by all countries when compiling and reporting data on the variable to multilateral databases such as the IEA database on access rates and the World Bank Development Indicators Database. Therefore, observations in data series may not have the same meaning across all countries in the three datasets.

Furthermore, reform indicators used in chapters were scored 2 and 3 as 0 if countries have not implemented either of the reform steps and 1 if otherwise. As pointed out in chapter 3, measuring reform steps this way does not reflect the degree, extent, or intensity of reforms implemented by SSA countries. Therefore, the reform indicators in chapters 2 and 3 do not capture whether reforms have succeeded or have failed. Second, the transmission and distribution losses as percentage of total electricity production used in chapter 2 as a proxy for technical efficiency (dependent variable). Using total generation as denominator to calculate losses[1] tends to over-estimate the variable because countries not only transmit and distribute what they generate but also the electricity imported from other countries. Therefore, the appropriate denominator to use in calculating the variable should be total electricity supplied rather that total production.

Similarly, in chapter 3, the ideology and privatisation indexes may be correlated and thus results should be interpreted with caution. Future research should use other methods to deal with this additional source endogeneity. Lastly, since electricity sector reform is a continuing process in SSA countries, the findings in this thesis cannot generalise since the reform scores used cannot cover all aspects of the reforms.

5.6. Suggestions for future research

In all SSA countries considered in this thesis, electricity sector market reform is an ongoing process especially as the reforms did not led to total withdrawal of governments from the sector. There are opportunities for future researchers to continue analysing the dynamics of these hybrid electricity markets. The hope is that future research will show whether the hybrid reform model leads to better outcomes compared to the standard model implemented in developed countries such as Chile and United Kingdom.

[1] The World Band development indicators, the United Nation energy statistics, the IEA and United States energy administration energy databases all report T&D losses as a percentage with respect to total electricity generation. Moreover, most empirical electricity efficiency studies used the T&D as percentage of total generation.

Due to the lack of data, the chapters focus on the reform progress rather than reform success or failure. Future research should investigate whether reforms have been successful, by developing reform indexes to measure regulatory quality, magnitude of private sector investments as well as the extent and intensity of reforms implementations. In the first empirical chapter, the ameliorating effect of reforms on the relationship between corruption and performance was investigated. The corruption index used in the chapter and as control variable in the two subsequent chapters may be biased. This is because, apart from the fact that corruption may mean different things to an average Ghanaian as opposed to the average South African, it is also possible that perceptions of corruption are influenced by perceptions of economic performance. Future studies should use other measures, where available, for instance data on the number of convictions reported by national judiciaries of SSA countries.

In chapter 4, the impact of electricity access on human development was investigated. I would have liked to have examined the impact of access rates on other indicators of wellbeing such as income inequality, gender and poverty which are noted to be among the factors constraining the socio-economic development of the region. This desire was limited by the lack of data. Although there are few studies that look at these issues in country case studies, a deeper analysis is needed to better understand the interactions between electricity access and human wellbeing especially in countries that reformed their electricity sectors.

Lastly, the fact that electricity reform is often part of wider economic liberalization policies, means that reforms may also impact other sectors of the energy industry as well. For instance, the dependence of Nigeria's electricity sector on the gas sector[2] implies that a shock to the gas sector will adversely affect the electricity sector. This shows that progress or reforms of other sectors will contribute positively or negatively to the progress or success of electricity sector reforms in SSA countries. In this research, I did not consider these possible

[2] In 2017, Nigeria's electricity mix was dominated by gas-fired power plants which contributes 74% of electricity generation with large hydropower dams contributing 25% (Emodi, 2017).

interactions between electricity sector reforms and other sectors or with other macroeconomic variables, and how these interactions would affect the performance of the electricity sector. These relationships are important research areas open to further exploration.

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Appendices

Appendix I-1: Types of Management of Contracts in SSA.

Table A1. 1: Types of Management Contracts in SSA

Country	Year of financial closure	Name of Project	Subtype of PPI	Project status	Segment
Chad	2000	Societe Tchadienne d'Eau et d'Electricite (STEE)	Management contract	Cancelled	G*, T** & D***
Gabon	1993	Societe Africaine de Gestion et d'Investissement (SAGI)	Management contract	Concluded	G, T & D
Gambia	1993	Management Service Gambia (MSG)	Lease contract	Cancelled	G, T & D
Gambia	2006	National Water and Electricity Company Management Contract	Management contract	Concluded	G
Ghana	1994	Electricity Corporation of Ghana	Management contract	Concluded	D
Guinea-Bissau	1991	Electricidade e Aguas de Guinea-Bissau	Management contract	Concluded	G, T & D
Kenya	2006	Kenya Power and Lighting Company Management Contract	Management contract	Concluded	T & D
Lesotho	2002	Lesotho Electricity Corporation (LEC)	Management contract	Active	G, T & D
Liberia	2010	Liberia Electricity Corporation Management Contract	Management contract	Active	T & D
Madagascar	2005	Jiro syRano Malagasy (Jirama)	Management contract	Concluded	G, T & D
Malawi	2001	Electricity Supply Corporation of Malawi Ltd (ESCOM)	Management contract	Concluded	G, T & D
Mali	1994	Electricite et Eau du Mali (Management)	Management contract	Concluded	G, T & D
Namibia	1996	Northern Electricity	Lease contract	Concluded	D
Namibia	2000	Reho-Electricity	Lease contract	Active	D
Rwanda	2003	Electrogaz	Management contract	Cancelled	G, T & D
Rwanda	2003	Electrogaz	Management contract	Cancelled	G, T & D
São Tomé and Principe	1993	Empresa de Agua e Electricidade	Management contract	Concluded	G, T & D
Tanzania	2002	Tanzania Electricity Supply Company (TANESCO)	Management contract	Concluded	G, T & D
Togo	1997	Companie Energie Electrique du Togo	Management contract	Concluded	G & D
*Generation, **Transmission and ***Distribution					

Source: World Bank PPI database

Appendix I-2: Robustness Analyses.

It is possible that the coefficient estimates in Tables 2.3, 2.4 and 2.5 may suffer from omitted-variable bias. Here we check the robustness of the results by adding additional explanatory variables in the model, one at a time to the three estimated equations to examine whether this would significantly affect the results.

Cubbin and Stern (2006) argue that a rapid growing share of industrial output (e.g., in heavy industry such as petrochemicals, aluminium, manufacturing) is expected to increase the demand for electricity. Similarly, Kaldor (1970) and Cornwall (1977) argue that expansion of the industrial sector is a driving force for economic development. Thus, excluding this variable (*ind*) from the estimated equations could, potentially, lead to biased estimates of the effects of ESR and corruption on the three indicators of performance. We therefore include the share of industrial value added as a percentage of GDP as an additional regressor in three equations. Several authors also find the degree of openness of an economy to influence electricity sector performance (e.g., Zhang et al., 2008). We also include exports (*export*) as percentage of GDP as an additional regressor in the performance equation. The data for *export* is obtained from the World Bank governance indicators database.

Furthermore, several studies include a variable measuring population density to assess the ability of both public and private utilities to extend low cost and affordable electricity to populations spread over vast areas (e.g., Ahlborg et al., 2015; Estache et al., 2009; Min, 2010). The data is from the World Bank development indicators database.

Results of this exercise are presented in Tables A1.2, A1.3 and A1.4. Columns 1, 3 and 5 of each table presents the parameter estimates of the models when *ind*, *export* and *popden* are added, one at time, as an additional regressors to the three performance regressions. The coefficients of *cor*, *ira*, *priv* remained significant/not significant depending on the

performance indicator with the expected signs regardless of the additional regressors added to the three equations. The only exception is *priv* in two of the energy losses equations, which shows a significant and positive coefficient while this was found not significant in Table 2.3. Similarly, the coefficients of the two interactions of interest, *iraXcor* and *privXcor*, remain significant/not significant in most cases (except the coefficient *iraXcor* in the per capita GDP equations and *privXcor* in one of the energy losses equations and one of the per capita GDP equations) regardless of extra additions to the three regressions.

Table A1. 2: Two-Step GMM Estimates of T&D Losses Equation

Technical Impact (*losses*)						
	ind		***ind + export***		***ind + export + popden***	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Variable	**Est.**	**t-stat.**	**Est.**	**t-stat.**	**Est.**	**t-stat.**
losses(t-1)	0.646***	3.93	0.477**	2.11	0.421***	2.82
cor	-30.031***	-4.38	-37.408**	-2.00	-35.648**	-1.97
ira	20.383***	3.07	50.552**	2.34	39.746**	2.57
priv	11.361	1.17	41.181*	1.70	49.538**	2.29
iraXcor	15.939*	1.94	28.549**	2.23	24.909***	2.69
privXcor	14.790	1.43	8.439	0.55	32.972**	2.32
iraXpriv	4.042	0.44	-26.730**	-1.98	-29.135**	-2.27
ln hols	-5.170***	-2.62	-2.241	-0.80	-6.426**	-2.05
struc	1.052	0.34	-2.082	-0.57	1.913	0.57
urban	0.304	1.11	0.587*	1.86	-0.030	-0.12
ind	-0.438	-1.02	0.236	0.90	0.498	1.54
export			-0.273**	-2.04	-0.582*	-1.73
ln popden					8.424***	3.26
time	-0.233	-0.94	-0.209	-0.58	0.603**	2.02
intercept	15.236	1.16	-50.491	-1.51	-18.420	-1.53
No of obs.		217		206		206
No of countries		22		22		22
Instruments		20		20		22
AR(1) test (p value)		-2.33 (0.020)		-1.68 (0.093)		-1.99 (0.046)
AR(2) test (p value)		0.73 (0.465)		0.21 (0.831)		-0.61 (0.544)
Hansen test (p value)		6.46 (0.487)		7.61 (0.268)		2.77 (0.906)

Significance code: *** p<0.01, ** p<0.05, * p<0.1

Therefore, we consider that the additional inclusions do not significantly alter the estimates of the coefficients for *cor*, *ira* and *priv*. Moreover, the estimates relative to the two interaction terms (*iraXcor* and *privXcor*) remain relatively stable regardless of which of the additional

variables is introduced in the performance equations. These results seem to indicate that the estimates presented in Tables 2.3, 2.4 and 2.5 are not suffering from omitted-variable bias.

Table A1. 3: Two-Step GMM Estimates of Per Capita Energy Consumption Equation

Welfare Impact (ln *access*)						
	ind		***ind + export***		***ind + export + popden***	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Variable	**Est.**	**t-stat.**	**Est.**	**t-stat.**	**Est.**	**t-stat.**
ln access(t-1)	0.916***	151.42	0.920***	121.58	0.915***	87.88
cor	0.093***	3.19	0.049**	2.22	0.068*	1.80
ira	0.084**	2.42	0.130***	5.60	0.127***	3.81
priv	-0.003	-0.08	0.036	1.47	-0.012	-0.35
iraXcor	0.044*	1.93	0.020*	1.89	0.077***	3.90
privXcor	-0.009	-0.23	0.038	1.25	-0.020	-0.49
iraXpriv	-0.081*	-1.72	-0.116***	-5.24	-0.091***	-3.01
ln *genper*	0.046***	5.59	0.031***	3.47	0.048***	4.43
ln *gdpper*	0.005	0.49	0.011*	1.69	-0.006	-0.38
struc	0.048***	3.70	0.047***	6.05	0.046***	4.72
urban	0.001***	3.65	0.001**	2.10	0.001	-0.55
ind	0.002***	3.90	0.001	1.29	0.002***	2.70
export			0.002***	5.61	0.001***	2.73
ln popden					-0.003	-0.70
time	0.002***	2.85	0.001*	1.71	0.003***	2.61
intercept	-0.141***	-2.59	-0.246***	-4.88	-0.069	-0.75
No of obs.		480		454		452
No of countries		45		44		44
Instruments		43		44		44
AR(1) test (p value)		-4.13 (0.000)		-4.10 (0.000)		-4.12 (0.000)
AR(2) test (p value)		-1.53 (0.125)		-1.59 (0.111)		-1.35 (0.178)
Hansen test (p value)		26.55 (0.596)		28.10 (0.512)		22.12 (0.776)

Significance code: *** p<0.01, ** p<0.05, * p<0.1

Table A1. 4: Two-Step GMM Estimates of Per Capita Income Equation

Economic impact (ln *gdpper*)						
	ind		***ind + export***		***ind + export + popden***	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Variable	**Est.**	**t-stat.**	**Est.**	**t-stat.**	**Est.**	**t-stat.**
ln gdpper(t-1)	0.466***	8.73	0.716***	14.41	0.824***	25.51
cor	0.199**	2.44	0.185***	3.51	0.085*	1.78
ira	0.050	0.55	-0.056	-1.21	-0.014	-0.22
priv	0.272***	3.38	0.080*	1.79	0.214***	3.69
iraXcor	-0.248***	-3.37	-0.116***	-6.66	-0.264***	-4.90
privXcor	0.239**	2.04	-0.016	-0.32	0.266***	4.27
iraXpriv	-0.116*	-1.72	-0.062	-1.27	-0.121**	-2.58
struc	0.163***	3.51	0.103***	5.37	0.098***	3.25
urban	0.016***	5.91	0.007***	3.29	0.005***	3.88
ind	0.007***	5.93	0.002***	4.38	0.002**	2.46
export			0.004***	4.83	0.002***	2.98
ln popden					-0.005	-0.39
time	0.001	-0.08	0.001	0.41	-0.001	-1.43
intercept	2.810***	10.76	1.587***	6.19	0.947***	4.96
No of obs.		480		454		452
No of countries		45		44		44
Instruments		42		43		39
AR(1) test (p value)		-2.29 (0.022)		-3.17 (0.002)		-3.01 (0.003)
AR(2) test (p value)		-0.66 (0.510)		-1.21 (0.226)		-1.13 (0.257)
Hansen test (p value)		26.38 (0.655)		20.35 (0.907)		21.06 (0.689)

Significance code: *** p<0.01, ** p<0.05, * p<0.1

Appendix II-1: Electricity Consumption Per Capita as a Proxy for Access

Table B1. 1: Two-Step GMM estimates of consumption per capita equation

Consumption per capita (ln *comper*)		
Variable	**Est.**	**t-stat.**
ln comper (t-1)	0.793***	10.43
ira	0.086**	2.14
left	0.045	1.05
right	-0.075	-0.68
priv	0.017	0.47
struc	-0.419***	-3.58
iraXleft	-0.070*	-1.94
iraXright	-0.006	-0.06
corr	0.038	0.72
ln gdpper	-0.279***	-2.99
ln gen	0.255***	4.64
urban	-0.003	-0.66
intercept	-1.602	-1.65
No of obs.		590
No of countries		45
Instruments		37
AR(1) test (p value)		-1.87(0.061)
AR(2) test (p value)		-0.66(0.512)
Hansen test (p value)		23.37(0.498)

Significance code: *** p<0.01, ** p<0.05, * p<0.1